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PROGRESSIVE ADAPTATION TO CORIOLIS ACCELERATIONS ASSOCIATED WITH 1-RPM INCREMENTS IN THE VELOCITY OF THE SLOW ROTATION ROOM

James T. Reason and Ashton Graybiel

JOINT REPORT

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SUMMARY PAGE

THE PROBLEM

The purpose of this experiment was to answer specific questions relating to the design of an adaptation schedule effective in protecting against motion sickness in a rotating environment. Ten men with normal vestibular function executed controlled head and body movements at each of ten 1-rpm step increases in the velocity of the Pensacola Slow Rotation Room. On the completion of each movement, subjects were required to indicate whether or not they had detected sensations of vestibular or somatosensory origin. At each velocity step, the movements were continued until each of twenty-four consecutive movements had elicited a negative response and the subject was judged to be symptom free. When this arbitrary adaptation criterion was reached, the angular velocity was increased by 1 rpm and the procedure repeated. On attaining the criterion at the terminal velocity (10 rpm), the rotation was stopped and the postrotatory phenomena were investigated using the same techniques.

FINDINGS

The principal finding was that the number of movements necessary to achieve the adaptation criterion was systematically related to the absolute level of angular velocity. Considerably more head and body movements were required to reach the same level of adaptation at faster speeds than at slower speeds, even though the size of the step increment remained constant. There was some evidence to indicate that the amount of stimulation to criterion depended upon the initial magnitude of sensation elicited by the increment. There were also wide individual differences in both the rate of adaptation and the minimum velocity necessary to evoke sensation.

RECOMMENDATIONS

The results suggest two findings that are relevant to the construction of an adaptation schedule:

1) Rotation may safely commence at 2 rpm.

2) The number of head movements necessary to achieve adaptation at each step velocity must be graded to the absolute speed of rotation in order to dispense with them in the most economic manner.

INTRODUCTION

This experiment was the first of a series designed to provide recommendations for the construction of an adaptation schedule that would give some residual protection against motion sickness on subsequent exposures to a rotating environment. Such a schedule has practical implications for the comfort and safety of astronauts aboard projected spacecraft that rotate to provide artificial gravity.

Recent investigations (1-3), using the Pensacola Slow Rotation Room, have shown that the motion sickness symptoms normally encountered on sudden exposure to Coriolis accelerations at 10 rpm can be minimized, or even avoided, if the same order of stimulation is approached gradually via a series of small velocity increments. These results indicate the feasibility of constructing a staircase-like adaptation schedule in which the subjects begin at a low level of stimulation and adjust to each intermediate step before going up to the next.

The design of an adaptation schedule which is both effective in preventing motion sickness and economical of time and effort poses a number of research problems. The present experiment was concerned with one such problem; namely, assuming that preexposure to Coriolis stimulation is necessary to develop protective adaptation, how much is required to achieve some definable degree of adaptation at each intermediate step velocity? The same question can be put in another way: Is the amount of stimulation necessary to achieve adaptation after each constant velocity increment a function of the absolute speed of rotation attained, or is it independent of that level? In other words, will it require more head movements to achieve the same degree of adaptation after an increment from, say, 9 to 10 rpm than it will after an increment from, say, 1 to 2 rpm? The answer to the question has important implications for the economy of the adaptation schedule as well as being of theoretical interest.

PROCEDURE

SUBJECTS

Ten men ranging from 18 to 30 years of age served as subjects. Eight of these were Navy enlisted men whose regular duties involved participating in experiments carried out at this laboratory, and the remaining two were civilian volunteers. A comprehensive medical examination revealed no significant abnormalities of labyrinthine function. The subjects differed widely in their susceptibility to motion sickness in a rotating environment.

APPARATUS

The major item was the Pensacola Slow Rotation Room (SRR), a circular windowless room 15 feet in diameter and 7 feet high. A more complete description of this room can be found elsewhere (4).

The subject was seated in a specially constructed chair facing toward the center column. The distance from the axis of rotation to the center of the subject's head in the upright position was 42 inches. Attached to the chair were four adjustable arms to which variable-position head pads were fixed. These arms and head pads could be adjusted so that with a combination of neck and torso flexion, the head could be placed at any angle up to 90° from the upright in each of the four quadrants: forward, back, left, and right. In addition, the chair was equipped with a detachable back-and headrest which could be secured during rest periods to restrain the head and provide support for the upper body.

To provide the subject with a structured visual field together with a fixation point at each head position, five rectangular sheets of paper marked off in squares and displaying a blue cross at the center (termed "test-patches") were placed at convenient positions around the subject. Three were secured to the center post parallel to the subject's frontal plane (in the upright position) at a distance of 35 inches from his eyes. The height of the center sheet was the same as that for the subject's head in the upright position, and the outside sheets were placed somewhat lower to correspond to head height in the left and right tilted positions. The fourth sheet was situated on the floor of the room immediately below the front head pad; the fifth was placed on the ceiling immediately above the back head pad.

The head and body movements were carried out at the direction of instructions delivered from a tape recorder. The recorder was situated within the room and was under the direct control of the experimenter.

METHOD

Head and Body Movements

These were grouped into sequences of eight discrete movements: the four "down" movements to each pad position plus the four "up" movements to the upright position. For each movement, the head passed through an arc of 90°, and the commands to move occurred at 2-second intervals. An interval of 4 seconds elapsed between the final movement in one sequence and the first movement in the next. During this interval the following sequence was identified by number. The order of the four "down" movements was randomized within each sequence.

Judgments of Sensation

In addition to making the 90° movements in response to the taped instructions, the subjects were required to make a forced-choice judgment at the cessation of each individual movement. One of two alternative judgments could be made, either "Yes," meaning that the subject had detected some sensation due to the rotating environment, or "No," meaning that he was unable to perceive the effects of the force environment. Two sensory components contributed to the Yes response: 1) those nonvestibular proprioceptive cues which told him that his head and torso were being deflected from their desired path during the movement, and 2) those sensations of vestibular origin that could be detected both during movement and at its cessation. The latter could be perceived either as apparent visual motion within the appropriate test-patch, or as sensations of whole-body movement. The negative response was appropriate when neither of these two sensory elements was detectable; i.e., when the sensations accompanying the movement were indistinguishable from those in a stationary environment.

Training and Instruction

Two types of training sessions were given at the beginning of the experiment to familiarize the subject with the sensations associated with each of the two possible judgments. First, the subject carried out a series of six to ten movement sequences while at rest. This procedure also gave practice in the task of making both movements and judgments in the correct temporal sequence. Second, each subject was taken to an angular velocity of 5 rpm where he made movements to each of the four head pads in turn. At the end of each movement he was asked to describe the nature of his sensations. It was then pointed out that if, during the experiment proper, he felt either one or a combination of these sensations, it would constitute the basis for an affirmative response. If, on the other hand, he experienced none of these sensations, and if the only sensations which accompanied the movement were those that he had felt during the previous session at rest, this experience would constitute the basis for a negative response. It was emphasized that, at each decision point, the subject was merely being asked to state whether he preferred the judgment Yes to that of No on the basis of the available sensory evidence.

The subject was also instructed to indicate whenever he became aware of the premonitory symptoms of motion sickness,particularly stomach awareness, increased salivation, and head discomfort. He was told that if this occurred, he would be rested until the symptoms had passed.

There were some exceptions to this instructional procedure. In the case of one subject known to be highly susceptible to motion sickness, the sensations elicited by the rotating environment were demonstrated at 3 rather than at 5 rpm.

Adaptation Criterion

The adaptation criterion was arbitrarily set at three complete sequences in which each of the twenty-four movements elicited a negative response. An additional qualification was that the subject should be apparently symptom free.

Summary of Operating Procedure

On completion of the training sessions, the SRR was returned to rest. The room then proceeded at 1-rpm steps to a terminal velocity of 10 rpm, or to a slower speed if the condition of the subject indicated that further increments would result in acute sickness. At each level of velocity, the subject continued to make the prescribed movements until:

1) he achieved the adaptation criterion, in which case he was given a 5-minute rest with head fixed after which he proceeded to the next step, or
2) he had completed 45 sequences without reaching the adaptation criterion, after which he was given a 5-minute rest period with head fixed and then continued, or,
3) he reported the onset of motion sickness, in which case he was allowed to rest with head fixed until the symptoms had passed and then continued.

On reaching the adaptation criterion at the terminal velocity, he was given a 5-minute rest period at the end of which the room was brought slowly to a rest. At rest, the subject proceeded to make the same movements in response to the taped instructions until he had achieved the adaptation criterion. At this point, the experiment was terminated.

RESULTS AND DISCUSSION

PERROTATIONAL ADAPTATION EFFECTS

The number of movement sequences prior to achieving the adaptation criterion at each level of velocity is shown for each subject in Table I. These values represent the total number of sequences executed at each rpm less the three sequences which made up the adaptation criterion. In general, the number of movements necessary to reach criterion increased as a function of the absolute speed of rotation. In two subjects, however, this trend was reversed. Subjects JE and SY appeared to require fewer sequences to criterion as the speed of rotation was increased. In the case of JE, it is possible that sufficient adaptation was accumulated in the first two steps to eliminate sensation in the subsequent steps; but in the case of SY, it seems likely that the number of sequences recorded bears little relation to the actual state of adaptation.

These results reveal wide individual differences in both the rate of adaptation and the threshold level (i.e., the angular velocity at which sensation was first reported). But there was no evidence for any systematic intrapersonal variation between adaptation rate and threshold. If anything, these findings suggest that the two factors were relatively independent of each other within any one individual. For example, subjects RE, HA, and WE were all characterized by a relatively slow rate of adaptation; yet RE and HA had relatively low thresholds, while WE revealed an extremely high threshold. On the other hand, subjects JE, SY, and DI all showed a relatively fast rate of adaptation, where both JE and SY indicated low thresholds while DI revealed a high threshold.

Four of the ten subjects were unable to reach the terminal velocity of 10 rpm. In the case of HE, the experiment was stopped because of the sudden onset of Malaise III (5) during a prescribed rest period after 45 sequences at 10 rpm. JA and SY were terminated because of recurring symptoms that were only partially alleviated by resting with the head in a fixed position. WE was stopped because of persistent stomach awareness and because he failed to show any evidence of adaptation after 225 sequences (1800 movements) at 5 rpm.

Table I

Number of Movement Sequences Prior to Achieving Adaptation Criterion at Each rpm*

Subject	1	2	3	4	5	6	7	8	9	10 rpm
RE	0	1	2	9	10	20	33	64	94	157
TA	0	2	3	2	3	9	10	5	8	8
HA	1	2	4	4	7	11	18	34	48	22
JE	5	4	0	0	0	0	0	0	0	0
HU	0	1	2	1	1	2	4	5	6	6
DI	0	0	0	2	2	2	2	3	3	4
HE	0	0	0	0	0	0	3	15	31	T+ (45)
JA	0	0	1	12	6	T (23)				
SY	8	7	1	1	1	T (10)				
WE	23	44	33	22	T (225)					

*This value represents the total number of movement sequences executed at each rpm less the three movement sequences, eliciting negative sensation, which constituted the adaptation criterion.

+T indicates that rotation was terminated without achieving the adaptation criterion. The figures in parentheses show the number of sequences completed prior to termination.

Only those data from the six subjects who reached the adaptation criterion at 10 rpm were used to derive an average adaptation schedule. The loss of information that this entailed seemed justified on two counts: 1) The performance of these six individuals was more likely to correspond to that of astronauts, and 2) the results from those subjects in whom the symptoms of motion sickness were severe enough to warrant ending the run prematurely suggested that there was a subtle interaction between the onset of symptoms and the process of adaptation which rendered the latter atypical.

Table II shows the total number of movement sequences prior to attaining the adaptation criterion at each level of angular velocity for each of those six subjects. Since the number of movements needed to fulfill the criterion at any given velocity was likely to be a complex function of the individual's total stimulation up to that point, this cumulative measure appeared a more meaningful indication of the process of adaptation than the values cited in Table I. For each rpm step, this measure was obtained by summing all the movement sequences (including those at lower angular velocities) that were required to reach the criterion at that level. Thus, the values corresponding to the terminal velocity (10 rpm) represented the total number of sequences executed by each subject in attaining the 10-rpm adaptation criterion (less the criterion sequences themselves); the same was true for each intermediate level of velocity. In view of the extreme values given by one subject (RE), the median was considered to be a more suitable measure of central tendency than the arithmetic mean.

Table II

Total Number of Movement Sequences Prior to Achieving Adaptation Criterion at Each rpm for the Six Subjects Who Reached Terminal Velocity of 10 rpm

Subject	1	2	3	4	5	6	7	8	9	10 rpm
RE	0	1	3	12	22	42	75	139	233	390
TA	0	2	5	7	10	19	29	34	42	50
HA	1	3	7	11	18	29	47	81	129	151
JE	5	9	9	9	9	9	9	9	9	9
HU	0	1	3	4	5	7	11	16	22	28
DI	0	0	0	2	4	6	8	11	14	18
Median	0	2.5	4.0	8.0	9.5	14.0	19.5	24.5	31.5	38.5
Quartile Deviation	0.5	1.0	2.0	4.0	7.5	11.0	19.0	35.0	57.5	66.5

The relationship between these median values and the angular velocity of the SRR is shown on logarithmic coordinates in Figure 1. The fact that the data points are well fitted by a single straight line indicates that the total number of sequences prior to criterion grows as a power function of the speed of rotation (exponent = 2.04). The implications of this finding for developing an adaptation schedule will be discussed at a later point.

On the basis of these findings, it seemed likely that the extent of the increase in subjective intensity associated with each constant increment in objective angular velocity might play a part in determining the number of sequences needed to reach criterion. Since no direct measure of subjective intensity was taken in the present experiment, it was not possible to test this notion directly; however, the question could be approached indirectly by assuming that the number of movements per sequence eliciting an affirmative response reflected the intensity of the stimulus. Thus, a stimulus which elicits Yes responses on all eight movements is assumed to be more intense than one which elicits affirmative responses on only one or two of the movements. To gain some idea of the variation in the initial strength of the stimulus over the range of angular velocities used, the mean number of affirmative responses per sequence was calculated for the first three

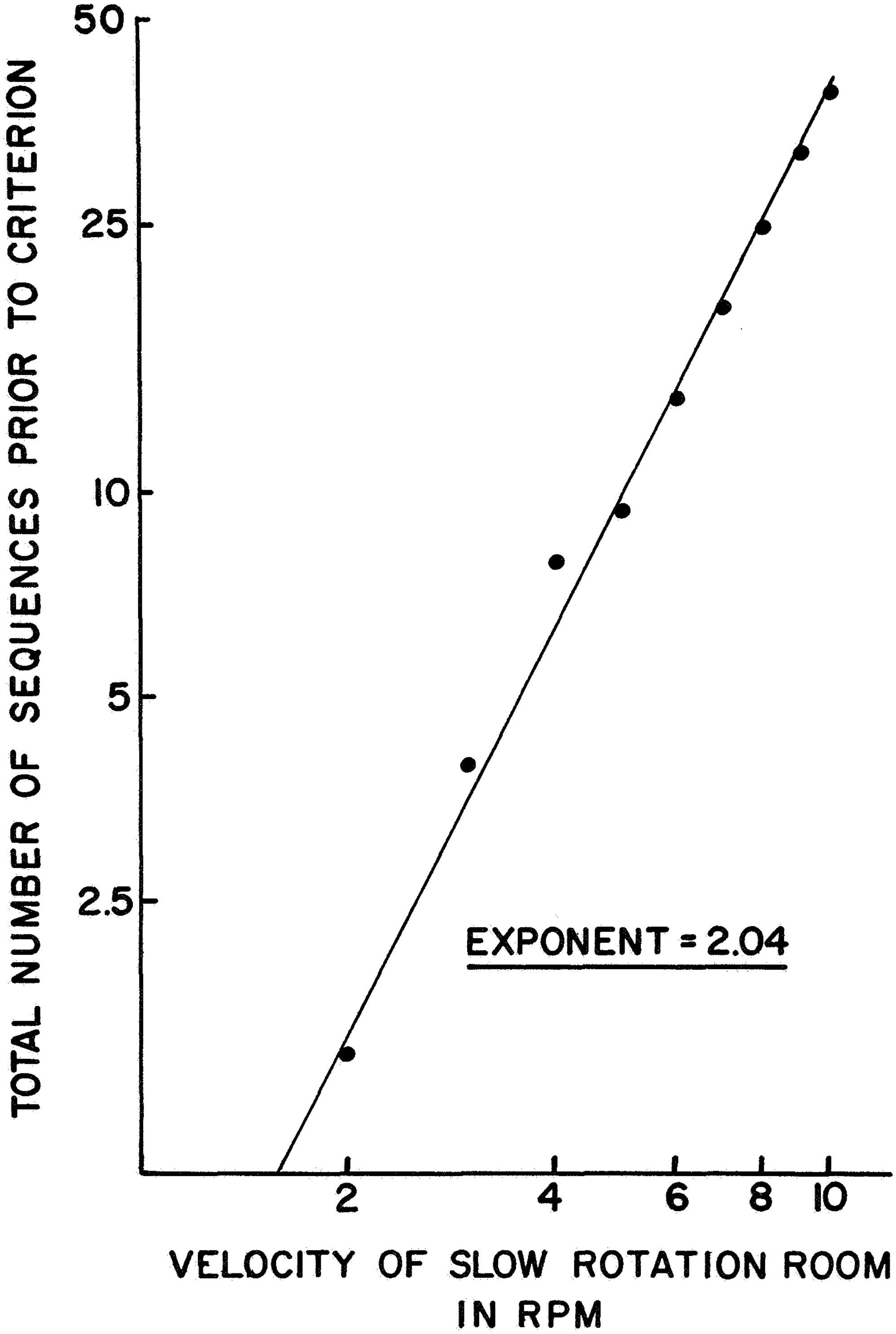

Figure 1

Relationship Between Median Total Number of Sequences Prior to Adaptation Criterion and Angular Velocity of SRR on Logarithmic Coordinates sequences at each rpm. These values are displayed graphically in Figure 2. It can be seen that the mean number of affirmative responses, in the first three sequences, grows in an approximately linear fashion with absolute angular velocity. This finding provides some support for the argument that the amount of stimulation required to achieve adaptation increases with the initial strength of the stimulus.

Another way to approach the same question is to consider how well the initial strength of the stimulus (as indicated by the mean number of affirmative responses per sequence over the first three sequences) predicts the number of sequences to criterion at any given level of velocity. Spearman rank order correlation coefficients were computed for each subject between the mean affirmative responses in the first three sequences and the number of sequences executed at each rpm. These coefficients are set out in Table III. It can be seen that, for most subjects, good predictions were obtained.

Table III

Spearman Rank Order Correlations, Within Each Subject, Between Number of Sequences Executed at Each rpm and Mean Number of Affirmative Responses per Sequence Over Initial Three Sequences at Each Velocity Level

Subject	Spearman Rank Coefficients r_s	P<	N*
RE	+0.95	.01	10
TA	+0.73	.05	10
HA	+0.97	.01	10
JE	+0.97	.01	10
HU	+0.95	.01	10
DI	+0.97	.01	10
HE	+0.98	.01	10
JA	+0.98	.01	6
SY	+0.60	NS	5
WE	+1.00	.01	5

*Where N is equal to the number of velocity steps for which data were available.

The initial strength of the stimulus is likely to be the predominant factor in determining the amount of stimulation required to achieve criterion only if the time-course of adaptation remains constant for each level of subjective intensity. To examine this, a sequential analysis was performed on the number of affirmative responses per sequence at different levels of angular velocity. The results of this analysis are summarized in Figure 3. The data points represent the mean number of affirmative responses per sequence (averaged over the available subjects) for sequences 1 through 10 at each step velocity. Two facts are evident from this analysis: First, the greater part of the decrement in

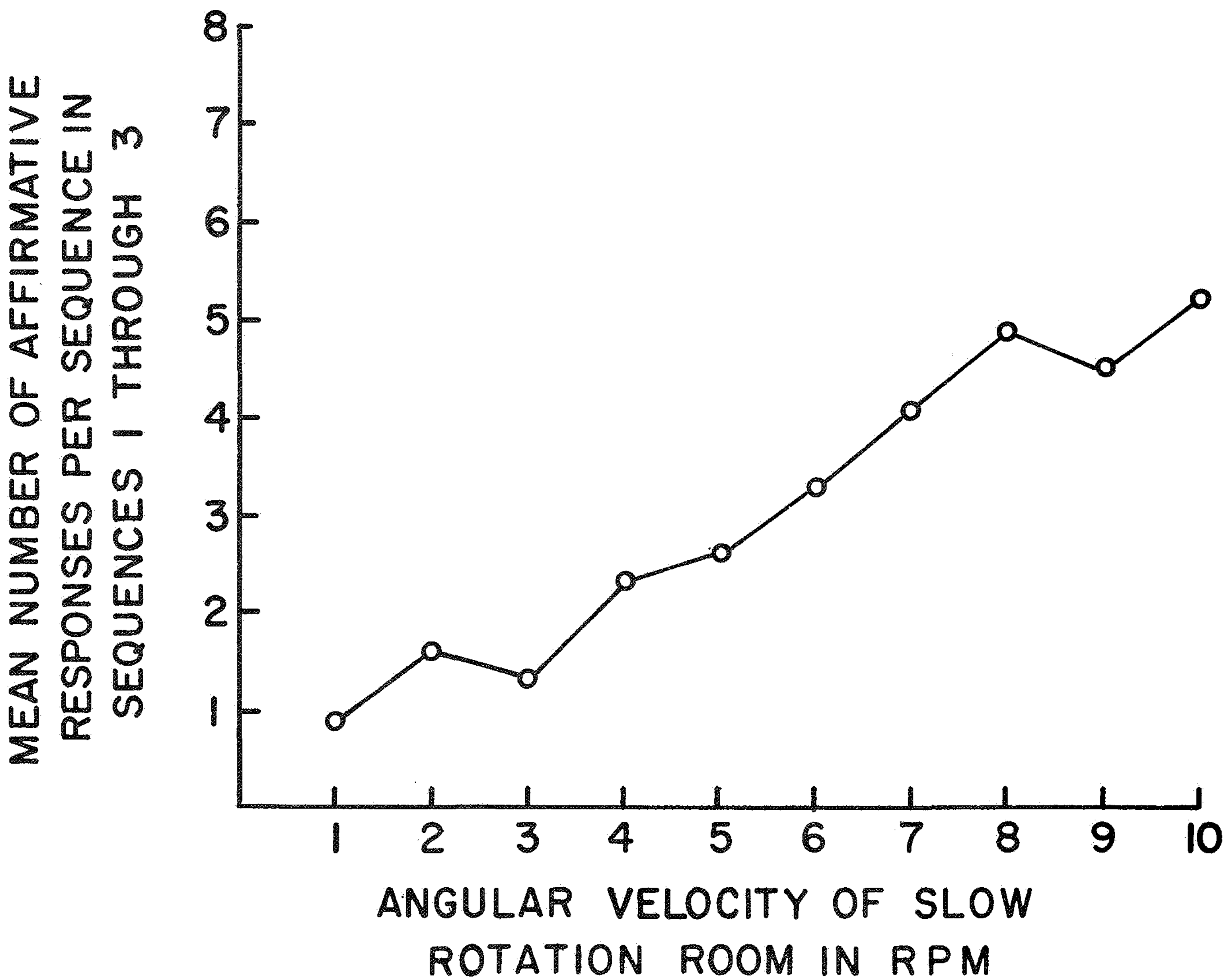

Figure 2

Relationship Between Mean Number of Affirmative Responses per Sequence in Sequences 1 through 3 and Angular Velocity of SRR

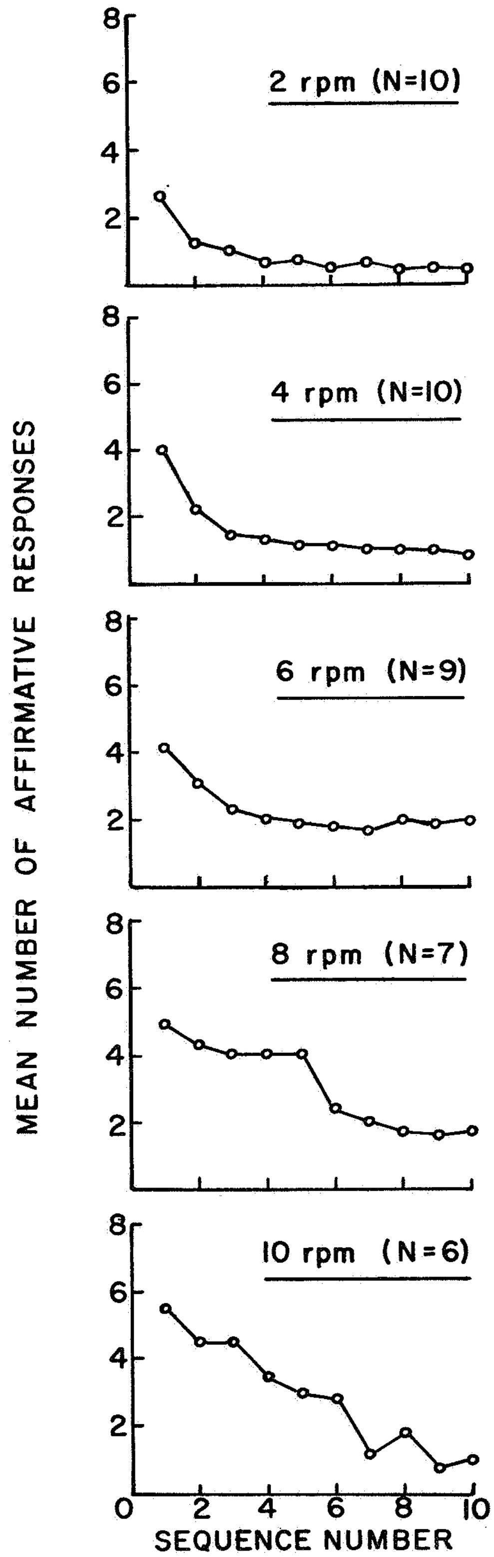

Figure 3

Sequential Analysis of Mean Number of Affirmative Responses per Sequence Over First Ten Sequences at 2, 4, 6, 8, and 10 rpm affirmative responses occurs quite early in the run; second, there is some tendency for the time-constant of response decay to lengthen with the absolute level of angular velocity. It would seem, therefore, that the amount of stimulation required to achieve adaptation at a given velocity level is a complex function of both the initial strength of the stimulus and the rate of response decay, where these two facts appear to be inversely related; i.e., the greater the initial strength of the stimulus, the slower the rate of affirmative response decay.

POSTROTATIONAL ADAPTATION EFFECTS

For the postrun condition (i.e., SRR stationary), the number of movement sequences required to achieve criterion for each subject (for whom data were available) is given in Table IV. In addition, measurements are given (where available) on the extent and direction of deviation of the head from the center of the pad following a single forward movement executed immediately following the cessation of rotation and before the sequences were commenced.

Table IV

A Summary of the Postrotational Findings

Subjects	Number of Sequences Prior to Adaptation Criterion at Rest	Extent and Direction of Head Deflection On Forward Movement*
RE	38	11 in. to left
TA	11	6 in. to left
HA	11	3.5 in. to left
JE	6	3 in. to left
HU	8	2.5 in. to left
DI	5	3.5 in. to left
HE	7	No measure
JA	0	1.5 in. to right
SY	No measure	No measure
WE	T (3) #	2 in. to left

*Immediately prior to commencing the postrun movements, each subject was required to make a single rapid forward movement to the front pad. He was instructed to aim for the center of the pad and to avoid correcting any torso deflection. The extent measure represents the distance from the midsagittal point to the center of the pad.

# Indicates that the run was terminated before achieving the adaptation criterion because of motion sickness. The figure in parentheses shows the number of sequences completed.

Of the eight subjects for whom posturn measures were obtained, seven reported sensations accompanying these movements. Judging by the direction of the head deflection, nonvestibular proprioceptive aftereffects were, with one exception (JA), in the opposite direction to those observed during rotation. The perrotational deviations were consistently to the right. The absence of postrun sensations in JA may have been due either to failure to adapt adequately to the perrotational stimulation, or the perrotational adaptation may have dissipated during the lengthy rest periods required by this subject to recover from motion sickness (a total of 240 minutes). Subject SY was too ill to perform the posturn movements, and severe symptoms after three sequences developed in subject WE which elicited strong sensations on all movements.

A Spearman rank correlation of +.93 ($p < .05$; N=6) was obtained between the number of posturn sequences prior to adaptation and the total number of sequences executed before achieving the adaptation criterion at terminal velocity (10 rpm). Assuming that the postrotational aftereffects reflect the degree of perrotational adaptation, this relationship indicates that those subjects who required a greater number of movements to reach the terminal criterion (i.e., who apparently adapted more slowly) acquired a greater degree of adaptation to the force environment than those who needed less movements to reach the same criterion. This suggests that the present criterion of three sensation-free and symptom-free sequences, although operationally equivalent for all subjects, did not necessarily indicate a uniform level of adaptation.

MOTION SICKNESS EPISODES

Symptoms of motion sickness occurred in seven out of the ten subjects at various points during the experimental session. In four subjects these symptoms were severe enough to require the premature termination of the experiment; in the remaining three instances the procedure of restraining the head for as long as the subject wished was sufficient to alleviate the symptoms and to allow him to complete the experiment. Details relating to these episodes are summarized in Table V.

In general, the symptoms progressed from a mild to a more severe malaise with continued exposure to the Coriolis accelerations. The Malaise I condition (5) (mild stomach awareness accompanied either by Pallor I or Sweat I, or both) was fairly easily identified in most cases and served as a useful index of when to stop the movements. Only in one case (HE) did relatively severe symptoms (Malaise II B) appear without prior warning. This case was also unusual in that symptoms appeared while the subject was taking a rest period with his head restrained; in all other instances, the symptoms were closely associated with the active head and body movements. The amount of time requested by the subjects to recover from symptoms varied widely both between and within individuals, and did not show any close relationship to the apparent severity of the episode.

As mentioned earlier, there was an indication that the presence of symptoms in some way interfered with the "normal" process of adaptation. In the case of WE, for example, an episode of Malaise I during the 3-rpm step appeared to reduce the number of movements required to achieve the adaptation criterion at that velocity, and at the

Table V

Summary of Motion Sickness Symptomatology

Subject	Occurrence	Symptoms	Recovery Time (min.)
TA	(a) Seq. 4, 8 rpm	Stomach awareness (SA); Pallor I (PI); increased saliva	6
	(b) Seq. 2, 9 rpm	As above	3
	(c) Seq. 2, 10 rpm	As above	5
	(d) Seq. 7, 10 rpm	As above	22
	(e) Seq. 4, postrun	As above	8
	(f) Seq. 7, postrun	As above	22
JE	Rest period* after 7 rpm	SA	15
HU	(a) Rest period, 10 rpm*	SA	19
	(b) Seq. 3, postrun	Nausea	20
HE	Rest period after Seq. 45, 10 rpm	Nausea, Pallor II, drowsiness	Rotation stopped
JA	(a) Seq. 9, 4 rpm	SA, sweat I (SI), dizziness	18
	(b) Seq. 12, 4 rpm	SA, PI, SI	105
	(c) Seq. 9, 5 rpm	SA, PI, SI	24
	(d) Seq. 8, 6 rpm	SA, PI, SI, severe dizziness	93
	(e) Seq. 23, 6 rpm	Persistent dizziness	Rotation stopped
SY	(a) Rest period* after 2 rpm	Headache, dizziness	5
	(b) Seq. 8, 6 rpm	Drowsiness, SA, PI, SI, dizziness	31
	(c) Seq. 10, 6 rpm	As above	Rotation stopped
WE	(a) Seq. 18, 3 rpm	SA	57
	(b) Seq. 113, 5 rpm	SA, SI, increased salivation	23
	(c) Seq. 180, 5 rpm	SA, SI, dizziness	31
	(d) Seq. 225, 5 rpm	As above	Rotation stopped
	(e) Seq. 3, postrun	Nausea, S II, P II, dizziness	Expt. stopped

*In these particular instances where symptoms were reported during the rest period, questioning of the subject revealed that they had been present during the latter part of the preceding movements.

subsequent 4-rpm level. This apparent anomaly may have been due to "latent" adaptation occurring during the requested rest period, or to interference from the symptoms themselves. There is also the additional possibility that some subjects chose to make "false negative" responses in order to escape an unpleasant situation. The inability to control for this behavior is one obvious drawback of the present method.

RECOMMENDATIONS FOR THE DESIGN OF AN ADAPTATION SCHEDULE

The fairly high incidence of motion sickness observed in this experiment indicates that the reported absence of sensation for three sequences did not constitute an effective degree of prophylactic adaptation in most cases. However, this criterion did provide an operational index of a given level of adaptation, and it is evident from the present findings that the number of sequences required to attain this level increases as a function of the absolute speed of rotation. Thus, the results shown in Figure 1 may be taken as an indication of the rate at which the number of movements must be increased at each additional step in the adaptation schedule, although they do not provide any information concerning the total number of head movements required to give protection against motion sickness.

In order to give some recommendation as to the proportion of sequences to be allocated to each of the ten steps in any future schedule, the predicted values (Y) were calculated from the regression equation describing the relationship in Figure 1 (i.e., $Y = 0.0671\ X^{1.73}$, where Y = predicted total number of sequences to criterion at that level, and X = rpm). Each of these values was then subtracted from that at the next high velocity (e.g., the Y value at 2 rpm was subtracted from that at 3 rpm; and so on), and these differences were expressed as a percentage of the median total number of sequences. The percentages obtained in this way are expressed diagrammatically in Figure 4.

Owing to the limited size of the sample, these recommendations are likely to be imprecise, and their generality limited to the conditions prevailing in the present experiment. However, they do have the merit of being based upon empirical rather than a priori foundations. More importantly, they offer two broad guidelines for the construction of an adaptation schedule: 1) that rotation can safely commence at 2 rpm (and even higher in some cases), and 2) that the number of movements necessary to achieve adaptation must be graded to the absolute speed of rotation in order to dispose of them in the most economical manner.

COMMENT

The present method of obtaining continuous sensation reports from the subject has shown itself to be a useful and workable technique for tracking the time-course of adaptation to Coriolis stimulation. The same technique can be employed in a variety of ways. For example, this method can be used to evaluate the effects of such variables as extent of movement, neck versus body flexion, active versus passive motion, the interval between movements, et cetera, upon the rate of adaptation in a rotating environment. The same method can also be used to examine the time for which effective protection persists

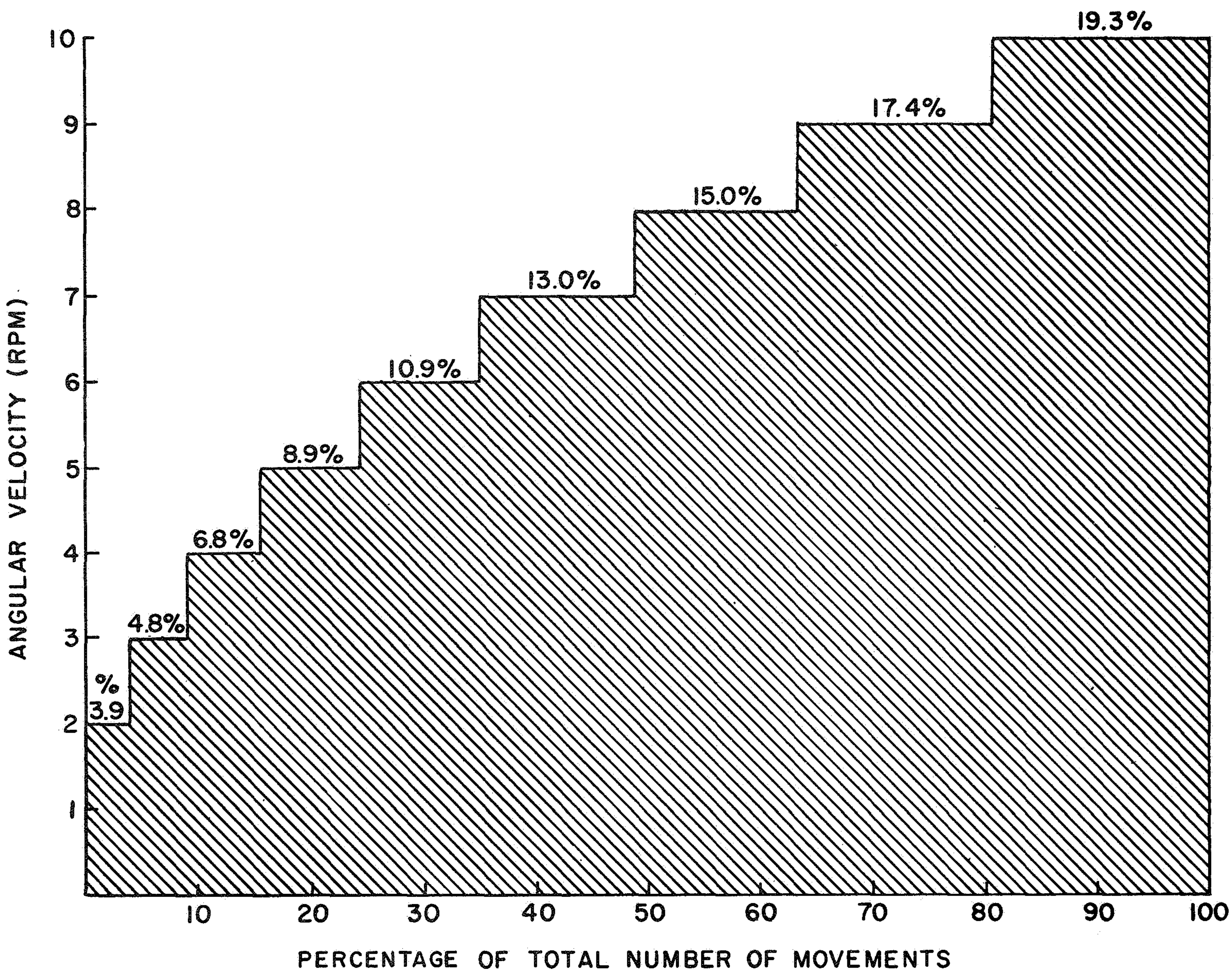

Figure 4

Recommended Percentage of Total Number of Movement Sequences to be Allocated at Each 1-rpm Step in Adaptation Schedule following the administration of an adaptation schedule. In an abbreviated form, it may form a useful part of a motion sickness test battery in that it offers a means of separating threshold information from the rate at which an individual adapts to Coriolis stimulation. Both of these factors are likely to be implicated in determining an individual's degree of susceptibility.

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13. ABSTRACT

The purpose of this experiment was to answer specific questions relating to the design of an adaptation schedule effective in protecting against motion sickness in a rotating environment. Ten men with normal vestibular function executed controlled head and body movements at each of ten 1-rpm step increases in the velocity of the Pensacola Slow Rotation Room. On the completion of every movement, subjects were required to indicate whether or not they had detected sensations of vestibular or somatosensory origin. At each velocity step, the movements were continued until each of 24 consecutive movements had elicited a negative response and the subject was judged to be symptom free. When this arbitrary adaptation criterion was reached, the angular velocity was increased by 1 rpm and the procedure repeated. On attaining the criterion at the terminal velocity (10 rpm), the rotation was stopped and the postrotatory phenomena were investigated using the same techniques.

The principal finding was that the number of movements necessary to acheive the adaptation criterion was systematically related to the absolute level of angular velocity. Considerably more head and body movements were required to reach the same level of adaptation at faster speeds than at slower speeds, even though the size of the step increment remained constant. There was some evidence to indicate that the amount of stimulation to criterion depended upon the initial magnitude of sensation elicited by the increment. There were also wide individual differences in both the rate of adaptation and the minimum velocity necessary to evoke sensation.

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