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Self-induced motion sickness in unperturbed stance

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ABSTRACT: Motion sickness typically occurs when the body is subjected to externally imposed motions, but there are situations in which sickness occurs in the absence of imposed motion. We report a new and unanticipated instance of the latter. Subjects in a study of spontaneous standing postural sway sometimes reported dizziness and motion sickness. Reports of sickness were correlated with changes in postural sway. We consider possible implications of these findings for two current theories of motion sickness etiology: the sensory conflict theory and the postural instability theory. © 1999 Elsevier Science Inc.

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INTRODUCTION

Motion sickness is most often associated with situations in which the body is subjected to imposed motion. Imposed motion can arise from movements of the support surface, as on a ship or other vehicle [13], and from relative motion between the body and the visible surroundings, as occurs in moving rooms [2,14,24] and in the presence of computer-generated optical flow fields [7]. Sickness resulting from imposed motion is known to be associated with motion within a narrow frequency band, 0.1–0.3 Hz [6,13,23].

Motion sickness also occurs in which there is little or no imposed motion. The most widely studied examples are sickness in weightlessness [21] or while wearing spectacles that introduce extreme optical distortions [e.g., 3]. Motion sickness can also be elicited under terrestrial conditions during activities that involve sustained angular motion. People can make themselves dizzy, and even ill, by rapid, vigorous twisting of the body or head [1]. Similarly, mild sickness is known to occur during or after a fast waltz, where it has been reported even among competitive ballroom dancers. In all of these cases, although there are no imposed motions, the body nevertheless moves in unusual ways. In weightlessness, the gravitoinertial force vector has a magnitude of zero and, hence, no direction [25]. This leads to dramatic and prolonged changes in the relation between behavioral intentions, actual motor output and sensory stimulation. Distorting spectacles are known to induce gross deficiencies in the control of body motion [4]. In other terrestrial situations, angular motion is nauseogenic only with large rapid displacements. These challenge our ability to control body motion and also produce atypical sensory stimulation.

In the present article we report the occurrence of motion sickness symptoms in standing subjects who were not subjected to any imposed motion nor to any form of sensory distortion or rearrangement. Their behavior produced minimal angular motion and included no vigorous activity, such as torso rotation [1]. Patterns of sensory stimulation and constraints on action did not appear to differ from ordinary standing.

We set out to study the effects of visual fixation on spontaneous postural sway [26]. Previous research had found that the amplitude of spontaneous sway was a function of the distance of the visible surroundings [3,14,22], with small sway amplitudes being associated with nearby surroundings and large sway amplitudes occurring with distant surroundings. Our hypothesis was that the amplitude of spontaneous anterior-posterior (AP) sway would be influenced by the distance of targets that were voluntarily fixated rather than by the distance of the surroundings *per se*. Specifically, we predicted that the amplitude of postural sway would be large when subjects fixated a distant target even when nearby objects were in the field of view. This prediction was confirmed [26]. In the present article we discuss only those aspects of the experiments that relate to motion sickness. The occurrence of motion sickness was noted but did not lead to any change in the purpose of the experiments, or to their design. The sole change (described below) was the addition of a questionnaire to record motion sickness symptoms for those who become sick.

Validity of Self-Reports

The appearance of symptoms among subjects came as a considerable surprise to us.[1] The experiments were not intended to induce sickness, so there was no experimenter-based demand character for the elicitation of false reports of sickness. There was also no demand character in the experimental instructions or procedure for the elicitation of false reports of sickness. There was no indication on any of the experimental materials (sign-up sheets, letter of informed consent, etc.) that motion sickness might be expected in the experiments. Subjects were not instructed about the possibility of motion sickness and were not told that the experiment would be discontinued if they experienced symptoms.

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[1] The occurrence of motion sickness in our experiments has elicited reactions of surprise from many of our colleagues, including motion sickness researchers. We have presented this research at scientific meetings, departmental colloquia and in informal discussions. There has not been a single instance in which, having been told of our experimental methodology but not the results, a scientist has suggested that our experiments might be expected to elicit motion sickness.

Subjects might have given false reports of motion sickness so as to gain early release from the experiment. However, the informed consent form stated that “you are free to stop participating in this experiment at any time and for any reason. You will receive full credit for your participation.” Thus, subjects who wished to terminate the experiment could do so without any reference (either false or true) to motion sickness.

There was little chance that subjects gave false reports of motion sickness based on “word of mouth” from other subjects. Subjects were drawn from the Psychology Department subject pool. The pool consists of undergraduates enrolled in Introductory Psychology courses, most of whom do not take any other courses in Psychology. Over the course of the study, the subject pool contained approximately 6,000 people. This makes it highly unlikely that experimental subjects had any prior knowledge that motion sickness might be a factor in our experiments.

For these reasons, we regard our subjects’ subjective reports as genuine. Indeed, the lack of apparent demand character for false reporting can be regarded as a significant advantage of the present study. The majority of research on motion sickness in humans relies on self-reports of symptoms from subjects who have been briefed to expect that motion sickness may occur, and thus are more likely to be aware of the opportunity for giving false symptom reports.

MATERIALS AND METHODS

Subjects

Forty-two undergraduate students at the University of Cincinnati participated in the experiments. The subjects ranged in age from 18 to 34 years and received course credit for their participation. All subjects had normal or corrected to normal vision. Subjects were asked if they had any history of disease or malfunction of the vestibular apparatus or of postural instability, recurrent dizziness or falls; only those who responded in the negative were retained.

Apparatus and Procedure

Data are reported from four experiments, which were designated *Monocular, Varying Distance, Partial Booth* and *Opaque Booth*. Trials and conditions are summarized in Table 1. In each experiment, subjects in a large room were asked to stand comfortably with their toes on a line. The room was sparsely furnished, with built-in cabinets extending 0.5 m from the right wall, wall-mounted shelves extending 0.25 m from the left wall and two large windows in the front wall covered by heavy shades (Fig. 1A). The room was 3.1 m high and illuminated from above by 12 built-in flourescent fixtures. Subjects were positioned so that their head was 3 m from the front and side walls of the room. The experimental manipulation consisted of asking the subject to fixate stationary targets at different distances. During fixation, the subject’s spontaneous postural sway was recorded using a 6-df magnetic tracking system (Flock of Birds, Ascension Technologies, Inc., Burlington, VT, USA). Head position was sampled at 50 Hz and recorded on a computer for later analysis.

In the Monocular experiment, subjects were asked to identify their preferred eye, which was covered by an eye patch. In all other experiments, viewing was binocular.

In two experiments (Partial Booth and Opaque Booth), the standing position was enclosed with a small booth (Fig. 1B). The booth was constructed of wood dowels and was 2.27 m high, 1.0 m wide and 0.77 m deep. The walls of the booth consisted of clear plexiglas on three sides. The plexiglas had a low gloss finish that tended to suppress reflections. There was no light source within the booth or behind it; this also served to minimize reflections. The booth was placed so that the subject’s head was 0.4 m from the front wall of the booth when their toes were on the designated line.

TABLE 1

SUMMARY OF EXPERIMENTS, CONDITIONS AND TRIALS

Experiment	*n*	Conditions*	Trials/ Condition	Total Trials
Monocular	12	Far—no object	4	12
		Far—object	4	
		Near	4	
Varying Distance	12	Far—no object	4	20
		Far—obj.; 0.4 m	2	
		Far—obj.; 0.8 m	2	
		Far—obj.; 1.2 m	2	
		Far—obj.; 2.0 m	2	
		Near; 0.4 m	2	
		Near; 0.8 m	2	
		Near; 1.2 m	2	
		Near; 2.0 m	2	
Partial Booth	9	Far—no object	4	12
		Far—object	4	
		Near	4	
Opaque Booth	9	Far—no object	4	12
		Far—object	4	
		Near	4	

* Far—no object, subject fixated the target on the wall of the laboratory but there were no nearby objects; far—obj., a nearby target was in place, but subjects were instructed to fixate the target on the laboratory wall; near, subjects were instructed to fixate the nearby target.

In the Partial Booth experiment, the plexiglas walls of the booth were partially covered. Small squares (1.5 × 1.5 cm) of granite-pattern contact paper were attached to the plexiglas. These squares covered 26% of the area, leaving 74% completely transparent, through which the room could be seen. For subjects standing in the partial booth spontaneous postural sway created global motion parallax involving relative motion between the partial texture on the booth walls and the distant walls of the laboratory. In the Opaque Booth experiment, the walls of the booth were completely covered with the granite-pattern contact paper, with only a small hole (35 × 31 degrees) in the front wall that permitted viewing of the far and near targets. As a result of this manipulation, global motion parallax was eliminated.

Subjects were asked to fixate nearby and distant targets. The distant target was an outlined area of the wall of the laboratory, having a visual angle of 18 degrees tall × 12 degrees wide. In the Monocular and Varying Distance experiments, the near target was the head of a photographic tripod (Fig. 2A). In the Monocular experiment, the tripod head was 0.4 m from the eyes, having the same visual angle as the far target. In the Varying Distance experiment, the tripod was placed, in different conditions, at distances of 0.4, 0.8, 1.2 and 2.0 m. At its farthest distance, the tripod head had a visual angle of 3 × 2 degrees. In the Booth experiments, the near target was a patch of granite-pattern contact paper affixed to the plexiglas front wall of the booth, having the same visual angle as the far target (Fig. 2B). In all experiments, the near target was positioned and height-adjusted for each subject so that from the subject’s position the top edge of the near target was aligned with the bottom edge of the far target (this allowed subjects to change fixation from one to the other with minimum adjustments of the eyes and head).

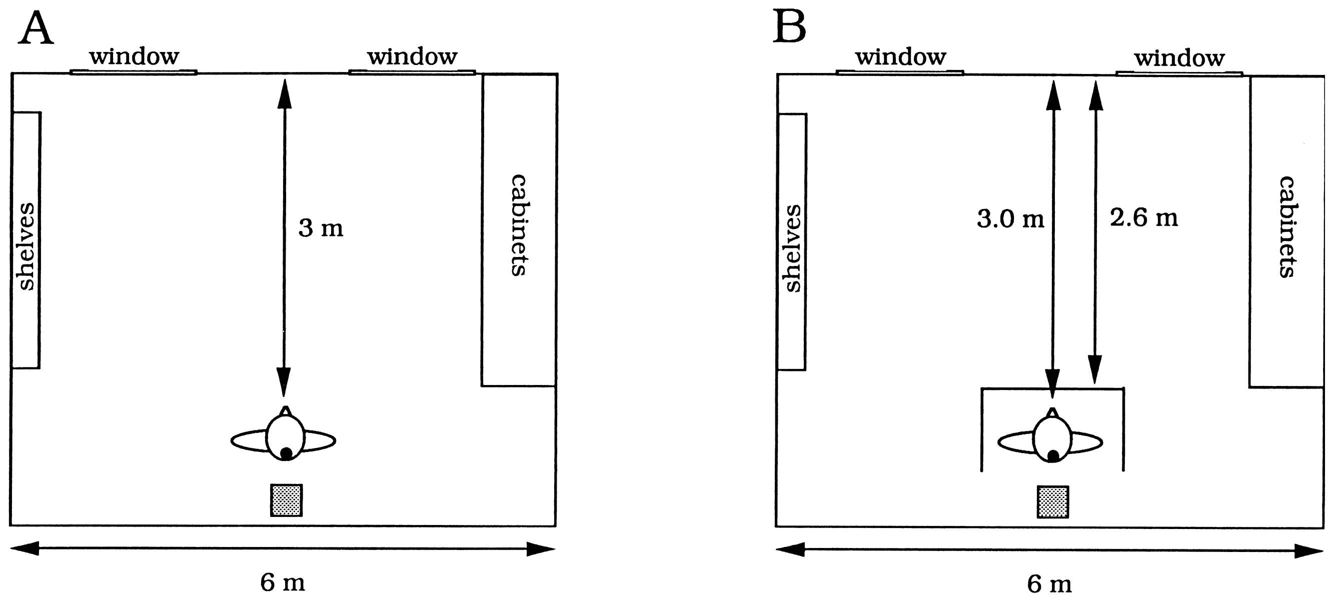

FIG. 1. General experimental setup. (A) Monocular and Varying Distance experiments. (B) Booth experiments. The shaded rectangle and black dot represent the magnetic emitter and receiver (respectively) for the tracking system.

Subjects were free to inspect the target but were instructed to try to limit their inspection to eye movements and to minimize head turns. For each experiment, conditions were arranged in random presentation orders: four different orders for the Varying Distance experiment and two orders for each of the other experiments.

Individual trials were 70 s in duration, with data recorded during the latter 60 s. Subjects were instructed to stand comfortably (with hands in pockets or clasped behind the back) and to "stare intently" at the designated target. They were not instructed to stand as still as possible or in any other rigid stance. Instructions explicitly noted that subjects were free to move about between trials. None elected to remove the bicycle helmet, sit or leave the laboratory, but it was common for subjects to move their feet, take a step forward and back or squat between trials. Combined with the brief duration of individual trials and the relatively small number of trials, this makes it unlikely that subjects suffered from blood pooling in the feet or corresponding drainage from the head. This is confirmed by the fact that there have been no reports of motion sickness in closely related experiments in our laboratory [5], using

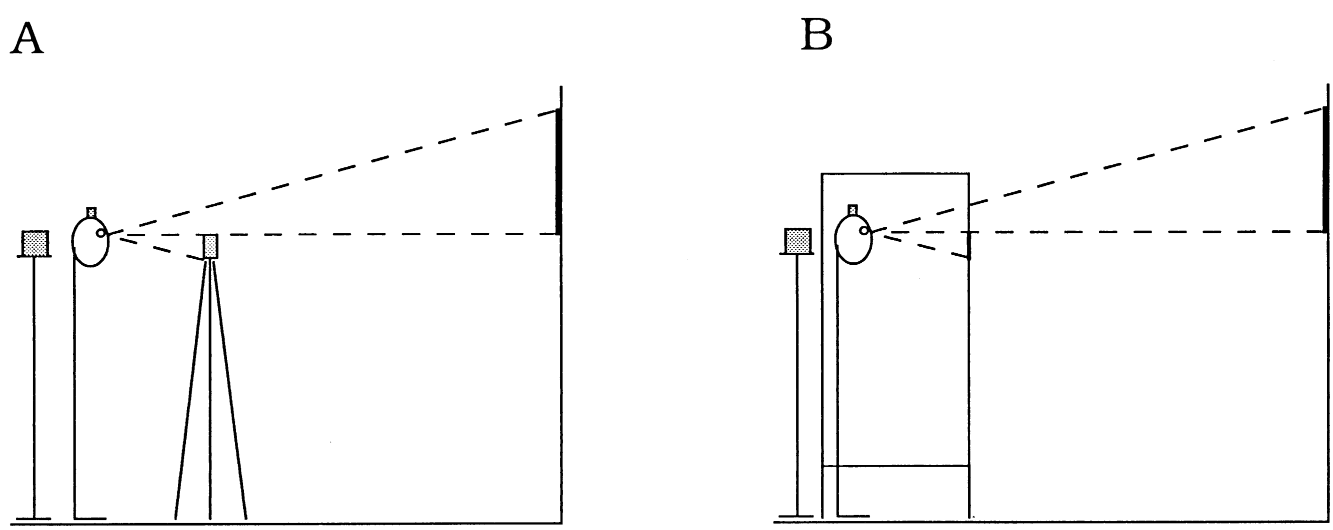

FIG. 2. Fixation targets. (A) In the Monocular and Varying Distance experiments, the near target was the head of a photographic tripod. In the Monocular experiment, the near target was positioned 0.4 m from the subject's eyes. In the Varying Distance experiment, target placement was adjusted across conditions (see text for explanation). (B) In the Partial Booth and Opaque Booth experiments, the near target was a rectangle of granite-pattern paper that was attached to the front wall of the booth, 0.4 m from the subject's eyes.

a similar number of 60-s trials. In these other experiments, subjects were exposed to optical flow created by movement of the visible surroundings.

As noted earlier, there was no indication on any of the experimental materials (sign-up sheets, letter of informed consent, etc.) that motion sickness might be expected in the experiments. Subjects were not instructed about the possibility of motion sickness and were not told that the experiment would be discontinued if they experienced symptoms.

The primary measure of motion sickness was self-reports. Because we were not expecting motion sickness, the first subjects reporting symptoms were not administered any formal measure of their symptomatology. After four subjects reported sickness, subsequent subjects who reported sickness were asked to fill out the Simulator Sickness Questionnaire (SSQ) [8]. The SSQ was selected as a scale that has undergone extensive validation and testing [8,9] and that is widely used in both laboratory and field studies of motion sickness [8,11,15,18]. The SSQ was used only by subjects who spontaneously reported symptoms. We did not collect any data on the subjective state of subjects who did not spontaneously report symptoms. Our rationale for this was to minimize the possibility of false reports of sickness (i.e., reports that might have been elicited or suggested by the fact of being asked to complete the SSQ). Subjects who did not report sickness completed the full set of experimental trials. Those who reported symptoms discontinued the experiment at the time of symptom report.

RESULTS

Motion Sickness Symptoms

Across the four experiments, nine subjects reported symptoms of motion sickness, for an incidence of 21%. Sickness incidence for each experiment was as follows: Varying Distance (3/12), Monocular (4/12), Partial Booth (1/9) and Opaque Booth (1/9). A chi-square test indicated that incidence was not significantly lower in the booth experiments.

Subjects reported tunnel vision, difficulty focusing, fatigue, difficulty concentrating, shakiness, headache, dizziness, faintness and increased temperature/sweating. Examples include "very dizzy, can't focus," "hard to focus, everything is gray," "very hot, dizzy" and "can't see straight, feeling dizzy." There were several explicit reports of nausea (e.g., "I think I'm going to be sick," "I feel like I'm going to throw up"). Because sickness was not expected, some of the early reports were not recorded immediately; this makes it impossible to give exact numbers of reports of particular symptoms. One subject grayed out and was unable to remain standing.

SSQ Scores

The SSQ was administered to five subjects who reported symptoms of motion sickness. The scores for each subject are presented in Table 2. Similar scores have been elicited by exposure to Navy and Marine Corp flight simulators [8]. A study of seasickness (20 people exposed to motion of a 93-foot patrol boat for 2 h in a bow-quartering sea) produced the following mean scores: nausea, 22; oculomotor, 12; dizziness, 10.5 [27].

Discontinuation

The number of trials completed for each subject who became sick is presented in Table 3. Six of nine subjects who became sick discontinued after less than 10 min (trials).

TABLE 2

SSQ SCORES FOR SUBJECTS REPORTING SYMPTOMS WHO COMPLETED THE SIMULATOR SICKNESS QUESTIONNAIRE

Experiment	Subject	Nausea	Oculomotor	Dizziness	TSS*
Monocular	SL	4	6	5	56.1
Monocular	KB	15	14	17	172.04
Monocular	JS	9	8	9	97.24
Partial Booth	GR	10	8	15	123.24
Opaque Booth	SW	16	13	15	164.56

*The total severity score (TSS) is not the sum of the subscale scores but is calculated differently [8].

Postural Motion

We analyzed the variability of spontaneous postural sway for sick and well subjects. As a measure of postural motion we used *v*, the variability (standard deviation) of the position of the head-mounted Flock of Birds receiver (we use the symbol *v* to avoid confusion, because we report both the mean and the standard deviation of positional variability). Before analysis the postural data were filtered using a low-pass Butterworth filter with a 4.0 Hz cutoff. We analyzed *v* separately for AP and lateral motion. Table 4 provides means across trials for each subject.

The postural data are summarized in Figs. 3 and 4. Because of differences in conditions across experiments and presentation orders within experiments, we were not able to conduct a statistical evaluation of trial effects. We conducted unpaired *t*-tests on *v* for sick and well subjects. The first *t*-tests compared the mean of all trials for well subjects against the mean of all trials for sick subjects (i.e., not averaged across subjects or trials). These revealed greater variability among sick subjects for AP sway ($t_{(557)} = 7.92$, $p < 0.01$) and for lateral sway ($t_{(557)} = 9.91$, $p < 0.01$). We next compared the mean across subjects for the final trial for which each subject participated. For the well subjects we used trial 12, so as to include all subjects who did not report sickness. For the final participation trial, sick subjects had greater variability in AP sway ($t_{(40)} = 3.79$, $p < 0.01$) and in lateral sway ($t_{(40)} = 3.22$, $p < 0.01$). Examples of individual trials are presented in Fig. 5.

We also compared experiments that used the booth with those that did not (Table 5). For the well subjects, *v* was lower for those who stood in the booth, for both AP and lateral motion (AP: $t_{(466)} = 4.88$, $p < 0.01$; lateral: $t_{(466)} = 3.14$, $p < 0.01$). By contrast, among sick subjects there were no differences in sway amplitude between those who stood in the booth and those who did not (AP: $t_{(89)} = 1.08$, $p > 0.05$; lateral: $t_{(89)} = 0.44$, $p > 0.05$). This may indicate that well subjects were sensitive to relevant dynamics of the booth (e.g., its physical distance from the body and the consequences of this distance for sway-related optical flow), whereas sick subjects were not [cf. 23].

DISCUSSION

Terrestrial motion sickness was reported by nine individuals who were not subjected to any imposed motion of any kind. The onset of symptoms was rapid, occurring after less than 20 min of experimental participation (in five cases sickness was reported after less than 10 min). This contrasts with reports of motion sickness following vigorous torso rotation, for which the minimum latency is 20 min from the beginning of torso rotation [1]. Subjects who reported sickness exhibited increased variability of postural

TABLE 3

DISCONTINUATION DATA FOR EACH SUBJECT WHO REPORTED MOTION SICKNESS SYMPTOMS

Experiment	Subject	No. Trials in Design	No. Trials Completed
Monocular	SL	12	7
Monocular	KB	12	6
Monocular	JS	12	10
Monocular	KC	12	4
Partial Booth	GR	12	7
Opaque Booth	SW	12	6
Varying Distance	CW	20	19
Varying Distance	JK	20	18
Varying Distance	OR	20	14

motion in both the AP and lateral axes. Because subjects were not asked to report motion sickness, it is possible that some subjects experienced motion sickness but did not report it. Thus, the true incidence of motion sickness may have been higher than is suggested by our data. The symptoms reported by our subjects resemble "vestibular effects" reported by office workers during manipulation of text and numerical data on video display terminals [7].

True Motion Sickness?

The statistically significant differences in postural motion between the "sick" and "well" groups provide objective evidence that there was some real difference between groups. However, given the absence of imposed motion, it is important to consider the possibility that subjects' subjective symptoms may have been caused by something other than motion sickness. Some symptoms that are associated with motion sickness are also associated with other, unrelated conditions, including various illnesses, eye-strain, etc. This reflects the fact that there is no precise, exclusionary definition of motion sickness (see, e.g., the debate over whether the symptoms experienced in weightlessness constitute true motion sickness [21]). Similarly, there is no measurement that indicates unambiguously that any given individual is motion sick, rather than experiencing any other disorder with similar symptoms. In the majority of motion sickness research (as in the present study), the

TABLE 4

VARIABILITY (ACROSS TRIALS) OF HEAD POSITION FOR EACH SUBJECT THAT REPORTED MOTION SICKNESS

Subject	*v*, AP	*v*, Lateral
SL	0.843 ± 0.157	0.378 ± 0.129
KB	1.316 ± 0.521	0.523 ± 0.198
JS	0.589 ± 0.152	0.416 ± 0.132
KC	1.097 ± 0.417	0.274 ± 0.064
GR	0.556 ± 0.107	0.648 ± 0.124
SW	1.341 ± 1.069	1.176 ± 1.000
CW	0.869 ± 0.155	0.919 ± 0.406
JK	1.283 ± 0.340	1.758 ± 1.943
OR	1.803 ± 0.713	1.054 ± 0.339
Mean	1.097 ± 0.584	0.962 ± 1.054
Mean of all well subjects	0.777 ± 0.401	0.373 ± 0.234

Values are means ± SD; expressed in cm.

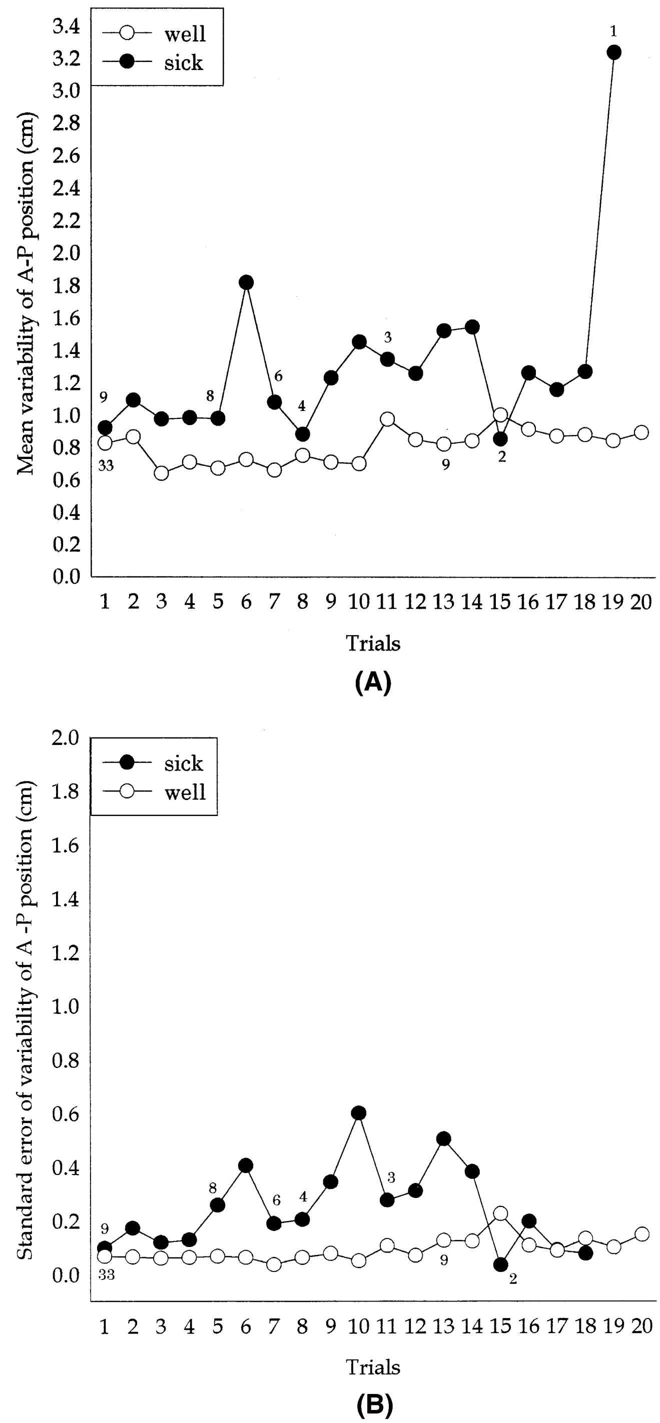

FIG. 3. (A) Mean variability (*v*) of AP head position for sick and well subjects, as a function of trials. (B) Standard error (across subjects) of AP head motion.

judgment that a person is motion sick is made primarily on the basis of their self-report, either in their own words or in responses to questionnaires [e.g., 1,2,6,8,11–17,21,24,27]. Thus, to question the reality of motion sickness in the present study may raise questions about the validity of self-report techniques in motion

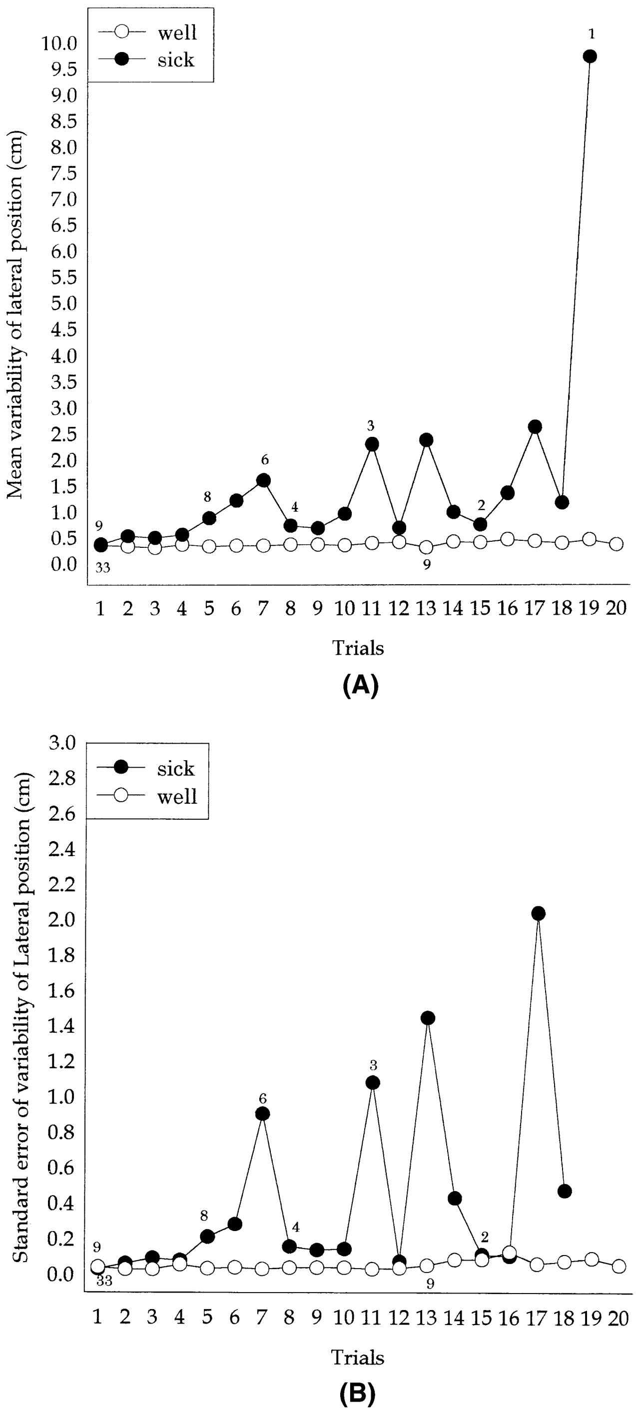

FIG. 4. (A) Mean variability (v) of lateral head position for sick and well subjects, as a function of trials. (B) Standard error (across subjects) of lateral head position.

sickness research in general. Reports of motion sickness in situations in which sickness was not expected by the experimenters [1,17] may help the scientific community reach greater concensus on a more rigorous definition of motion sickness, and on more precise operational metrics for motion sickness. It is interesting to note in the present study that the profile of the subscale scores of the SSQ (Disorientation > Neurovegative > Oculomotor; see Table 2) resembles that of sickness produced by virtual environment systems [9].

Theoretical Perspectives

The apparent occurrence of motion sickness in our experiments does not fit comfortably within the sensory conflict theory of motion sickness. In this theory [e.g., 19,20], motion sickness is caused by discrepancies between current sensory inputs and expected inputs. Discrepancies typically occur when different sensory systems (e.g., vision and the vestibule) or different parts of a single sensory system (e.g., otoliths and semicircular canals) indicate different and incompatible states of motion of the animal. Motion sickness is predicted to occur when the magnitude of sensory conflict exceeds some threshold value. According to Oman [19,20], low-magnitude sensory conflict is a nearly constant feature of daily behavior. The existence of a magnitude threshold is needed to account for the fact that this low-magnitude conflict does not produce motion sickness (i.e., we are not constantly motion sick in daily life).

The magnitude of any sensory conflict generated by visual fixation and postural sway in our laboratory should have been extremely small. For instance, if there were conflict associated with our task, it should be lower in magnitude than that associated with many ordinary behaviors that are not associated with self-induced motion sickness (e.g., walking, riding a horse, doing gymnastics). Thus, any threshold whose purpose is to suppress conflict arising from ordinary behavior should have been effective in our experiments. In addition, the rapid onset of symptoms (in most cases, after less than 10 min) would appear to preclude significant build-up of conflict within the system. For these reasons the present findings pose a problem for any theory in which motion sickness is related to the magnitude of sensory conflict, or to thresholds that suppress low-magnitude conflict.

We are not aware of any treatment of the sensory conflict theory that has made a prediction that postural sway in the absence of any externally-imposed motion could lead to motion sickness under any terrestrial conditions. Such a prediction would not violate the logic of the sensory conflict theory, and so might be developed. This may represent a challenge for the sensory conflict theory. It would be necessary to explain how any conflict produced in our experiments would be greater in magnitude than conflict produced in other conditions of unperturbed stance that do not elicit motion sickness.

It might be argued that postural sway in the booth gave rise to sensory conflict due to reflections from the plexiglas booth walls. However, this explanation would not apply to the seven subjects who reported sickness in the Monocular and Varying Distance experiments, in which the booth was not used. Postural sway during stance in the partial booth produced unusually high levels of global motion parallax. It might be argued that this unusual visual stimulus created enough sensory conflict to exceed the threshold for motion sickness. Again, this argument would not apply to subjects who reported sickness in the other three experients. Finally, the use of an eye patch in the monocular experiment may have produced sensory rearrangement that might underlie sickness, but this too would not account for sickness in the other experiments. None of these possible sources of rearrangement or conflict can account for the occurrence of symptoms in the varying distance experiment, in which the sole manipulation was the distance of fixated targets.

The postural instability theory of motion sickness [23] proposes that the symptoms of motion sickness result from instability in the control of the body. A key prediction of this theory is that postural

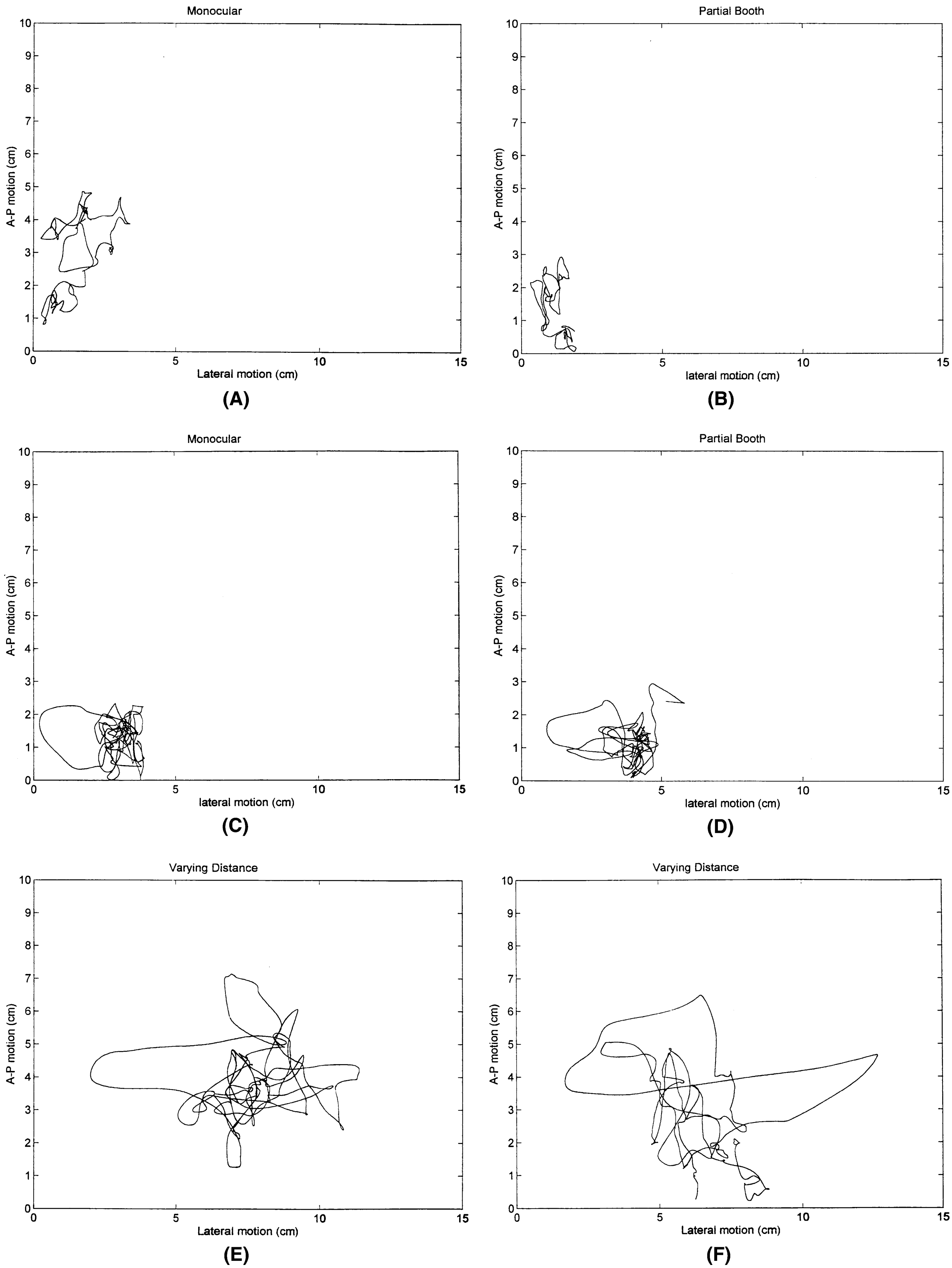

FIG. 5. Sample records of head motion for individual trials. (A and B) Subjects who did not report motion sickness. (C–F) Subjects who reported motion sickness.

TABLE 5

v POSITION ACROSS SUBJECTS AND EXPERIMENTS

	AP		Lateral	
	Partial Booth and Opaque Booth	Monocular and Varying Distance	Partial Booth and Opaque Booth	Monocular and Varying Distance
Well	0.673 ± 0.315	0.848 ± 0.424	0.333 ± 0.175	0.399 ± 0.259
Sick	0.947 ± 0.833	1.123 ± 0.533	0.934 ± 0.762	0.980 ± 1.112

Values are means ± SD; expressed in cm.

instability must begin before the onset of symptoms. Data from the present study cannot be used to evaluate this prediction, since subjects were not told to discontinue participation at symptom onset (we do not know whether the changes in postural motion preceded the onset of symptoms). If postural instability did precede the development of symptoms, we would consider this a case of motion sickness being caused by postural instability. The question, then, would be what aspects of the experiments promoted the development of postural instability. One possibility is that there may have been a conflict, not in sensory stimulation, but between the control of posture and the control of visual fixation. This is related to the hypothesis that postural sway may be controlled so as to facilitate performance on the supra-postural looking task [26]. Subjects were instructed to "stare intently" at nearby and distant targets, and this may have placed unusually high demands on the control of posture, particularly during fixation of distant targets, which is often associated with increases in postural sway [14,22, 26]. The instruction to maintain precise fixation on a distant target may have caused subjects to attempt to limit postural sway below magnitudes that they could detect; such a conflict between behavioral goals and perceptual sensitivity might lead to unstable control of posture. This suggests that a less demanding visual task might reduce or eliminate sickness.

CONCLUSION

It would be desirable to conduct additional research to investigate further the occurrence of motion sickness in our seemingly innocuous experimental situation. However, it is not possible to replicate the existing studies exactly. Following the termination of the experiments we reported the unexpected occurrence of motion sickness to the university human subjects committee, which required us, in future research, to revise our informed consent form to alert subjects to the possibility of motion sickness. In our opinion, a central feature of the present studies is that there was no demand character of any kind that might have encouraged false reporting. This essential feature must be absent from any future studies of motion sickness in this situation.

The present data document the existence of terrestrial motion sickness symptoms in the absence of externally-imposed motion or vigorous self-generated motion. This resembles a report of motion sickness during extended use of video display terminals [17]. These findings may motivate further studies of similar phenomena. Would labyrinthine-defective persons be susceptible to self-induced motion sickness in unperturbed stance or in weightlessness? What is the relation between self-induced motion sickness in terrestrial and weightless environments or in instances where sensory information is rearranged (distorting lenses)? The apparent occurrence of motion sickness in the absence of nominally provocative sensory stimuli suggests that for our subjects (at least) sickness may have had its source in nonsensory factors. Differences in sickness across subjects may have been due to differences in their behavior, as proposed by Riccio and Stoffregen [23]. Methodologies that correlate subjective symptomology with measurable behavior may help to elucidate the circumstances under which sickness can be induced without externally-imposed motions. It is clear that self-induced motion sickness is a rare and atypical phenomenon [1,17]. However, our discussion suggests that it may have important implications for the testing of theories of motion sickness etiology.

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