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# SPACE ADAPTATION SYNDROME EXPERIMENTS
(8-IML-1)

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This set of seven experiments will study adaptation of the human nervous system to weightlessness, with particular emphasis on the vestibular and proprioceptive systems.

## Sled/H-Reflex Experiment

The absence of gravity must cause human otolith organ function to be altered significantly. These changes should be reflected in modified vestibulospinal reflexes. In this experiment, subjects will be exposed to sinusoidal linear motion as a stimulus to the otolith organs. H-reflex testing will be used to detect resulting modulation of spinal cord excitability. This approach will make it possible to determine how vestibulospinal reflex function changes during and after exposure to weightlessness (even if those changes are subthreshold), free of contamination by voluntary motor activity.

Wearing ear plugs and a blindfold to eliminate sound and visual cues, a test subject for the Sled Experiment is strapped into a seat on a device called the mini-sled (Figure 1). The seat slides gently back and forth along two rails for a maximum distance of 100 cm (40 in.) to provide a linear acceleration stimulus to the otolith organs. The test subject is further outfitted with electrodes that stimulate reflexive muscle responses in the leg. One electrode placed behind the subject's knee applies small electric shocks to the leg, and electrodes placed over the calf muscles record the responses. Acting through usual reflex pathways, the acceleration stimulus to the inner ear changes the response to the electrical shocks in the leg, and thus, it is possible to measure otolith activity in an alert human being with a functional vestibular system. To study the two independent receptors that make up each otolith organ, the subject is accelerated back and forth while seated upright and while positioned on the back.

A computer records all results during the experiment, and the data are analyzed after landing. If the nervous system learns to reinterpret the modified sensory information from the otoliths, acceleration stimuli to the inner ear should continue to influence the response recorded in the leg. If the nervous system learns to ignore that information, the variation in leg responses should gradually disappear.

## Rotation/VOR Gain Experiment

There are several reasons why the vestibulo-ocular reflex (VOR) and other components of gaze control may be abnormal in weightlessness. These abnormalities could be an underlying cause of the Space Adaptation Syndrome since an unstable retinal image usually leads to motion sickness. Subjects will use self-generated head movements to stimulate their semi-circular canals. Eye and head rotations will be measured and the gain of the VOR calculated. The subjects will also perform a gaze refixation task to evaluate eye-head coordination in weightlessness.

Strapped into the stationary mini-sled seat, the test subject wears electrodes and measuring devices that record head and eye movements (Figure 2). In the first test, the crew member looks at a target, closes the eyes, rotates the head to the side while trying to keep the eyes pointed at the unseen target, and then opens the eyes. The effectiveness of the vestibulo-ocular reflex is determined by how close the subject's gaze is to the target when the eyes are opened. In a complementary test, the subject, with eyes closed, oscillates the head from side to side or up and down while trying to keep gazing at an imaginary fixed target. The subject's ability to keep the eyes pointed at the target is a measure of the reflex effectiveness. Finally, the subject is asked to move the head and eyes as necessary to look at a spot of light which reappears in different locations on a screen.

In this experiment. all results are recorded on an analog tape and analyzed after flight.

## Visual Stimulator Experiment

Subjects exposed to steady rotation of their visual field experience an illusion of self-motion known as circularvection. There is now evidence that in the absence of a gravitational reference, the phenomenon is enhanced as visual inputs become relatively more important than vestibular inputs. This experiment builds on the previous studies of Young and should lead to increased understanding of this important mechanism whereby the nervous system compensates for disrupted vestibular function in space.

The subject on the stationary seat of the mini-sled faces a dome-shaped, randomly patterned rotating visual field with its rim 2 inches ahead of his eyes. This position leaves a narrow rim of the outside world still visible around the periphery of the dome, which has been found to enhance the circularvection illusion, and to simplify the tracking task. The stimulus will consist of constant speed rotation of the device at 30, 45, or 60 degrees per second, in one direction or the other, for about 40 seconds. During the application of the visual stimulus, the subject will develop a feeling of self-rotation, accompanied by apparent rotation of the small part of the outside world which he can see in his peripheral vision, beyond the dome rim. The subject's task will be to rotate a crank attached to a 360 degree precision potentiometer, matching crank angular velocity to the apparent rotation velocity of the outside world.

A computer will monitor and record both dome speed and crank speed and the strength of circularvection will be calculated by comparing these signals.

## Proprioception (Relaxed) Experiment

Anecdotal reports and the results of previous flight experiments provide a body of evidence suggesting that proprioception is degraded in weightlessness.

In this experiment, an observer moves the head, arm, or leg of a blindfolded test subject, who remains passive during the movements (Figure 4). The observer bends the joint first to a reference angle and then to a slightly different angle. The subject must determine whether the second angle is larger or smaller than the reference angle, then move the joint and finally set it back to the second angle. A goniometer measures the actual angles which are recorded by computer.

The methods used will allow the determination of proprioceptive thresholds, and should detect interactions occurring between the proprioceptive, vestibular, and motor systems, during and after prolonged exposure to weightlessness.

## Proprioception (Active) Experiment

There appears to be an unusual degree of loss of sense of orientation and of perception of body image in the absence of both gravity and vision. Body image perception seems to improve following active muscular contractions. Using a pointer similar to a flashlight, the subject will point at a series of memorized targets during a prolonged absence of vision (Figure 5). A second crew member records how closely the light beam comes to each target. This test is repeated with the subject's eyes closed only during the extension, pointing, and retraction of the arm. This will make it possible to separate errors caused by degraded proprioceptive ability from those resulting from a distorted image of the outside world. This should determine if the perceptual errors are the result of faulty sensory inputs or if they have a more complex cause.

## Proprioception (Illusions) Experiment

Some crewmembers from previous space flight missions have described illusions in which hopping up and down resulted in a feeling of the floor moving up and down like a trampoline underneath them. This could be the result of inappropriate motor commands, incorrect sensory feedback, or modified interactions between the two. In this experiment, subjects will perform several types of rhythmical motor activity, note any resulting proprioceptive illusions, and determine the effects of vision and tactile inputs on these illusions (Figure 6).

## Tactile Acuity Experiment

During prolonged space flight, as unloaded intervertebral discs expand, astronauts become several centimeters longer. This could lead to pressure blocks of nerve roots. In this experiment, tactile acuity will be measured in one finger and one toe with the aid of metal blocks having surfaces on which parallel ridges are spaced increasingly close together (Figure 7). The subject is required to distinguish by touch alone the direction of the unseen ridges.

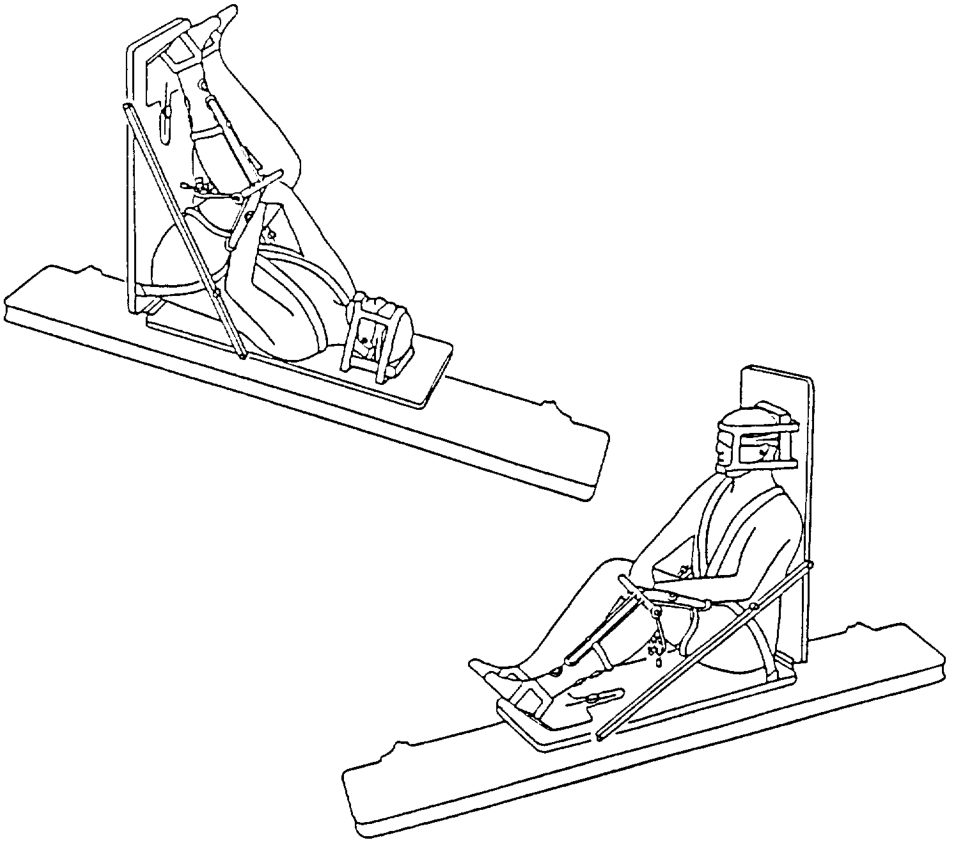

Figure 1. SLED/H-Reflex Experiment.

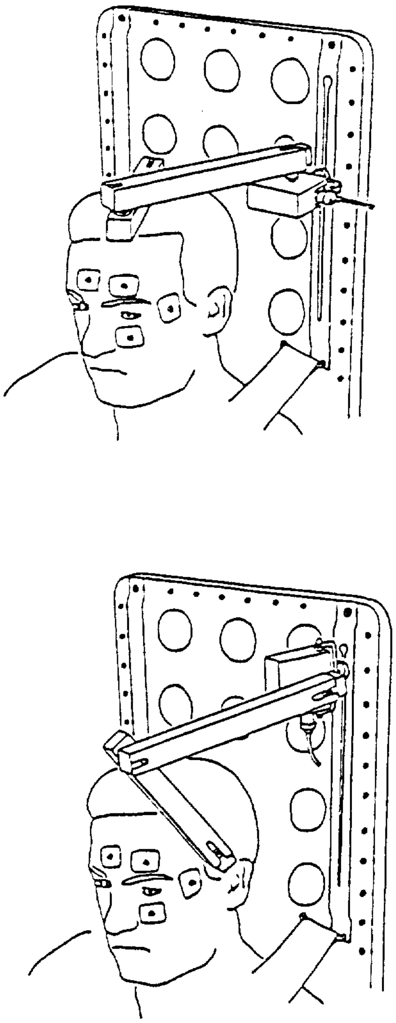

Figure 2. Rotation/VOR Gain Experiment.

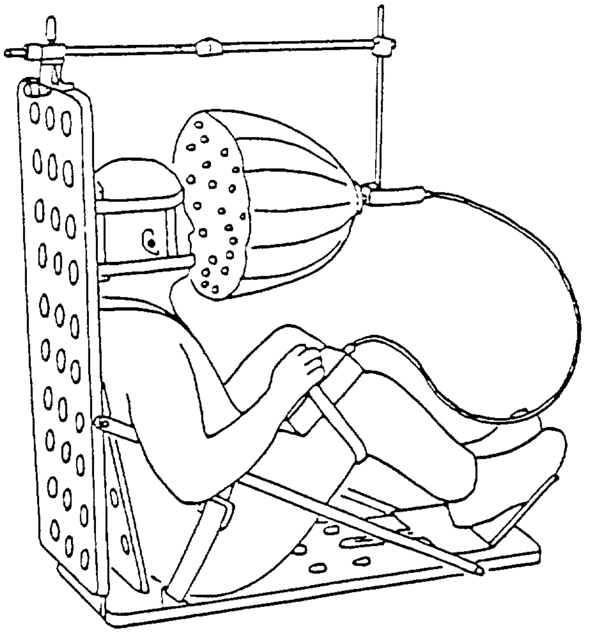

Figure 3. Visual Stimulator Experiment.

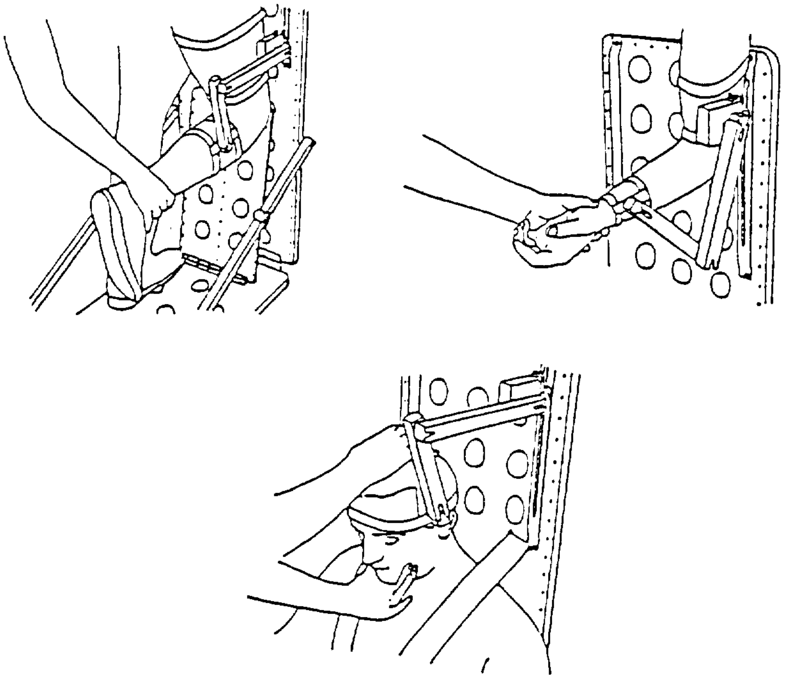

Figure 4. Proprioception (Relaxed) Experiment.

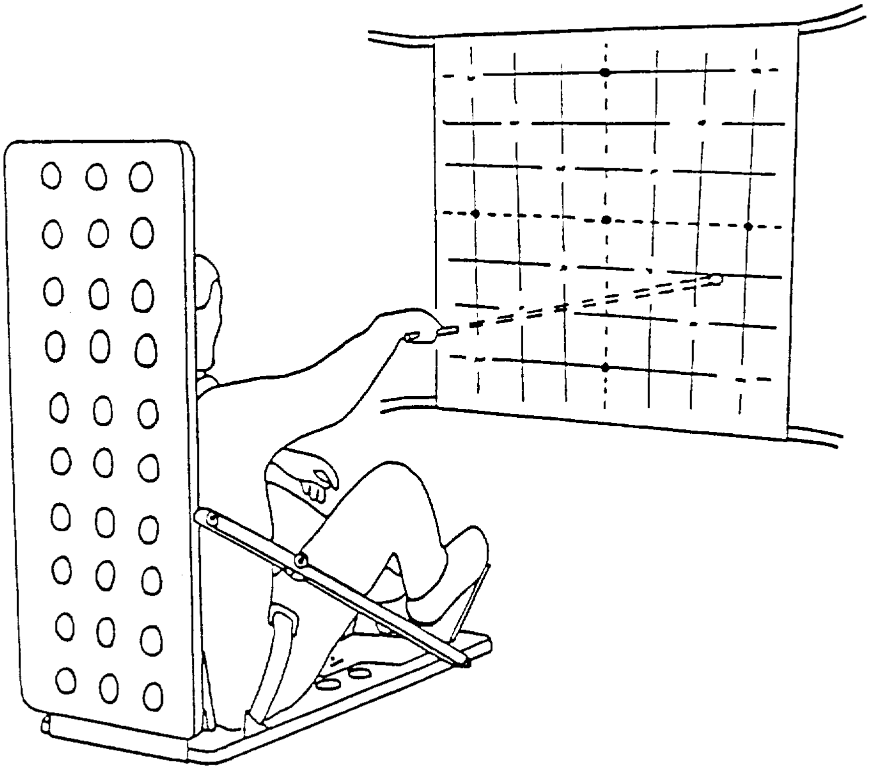

Figure 5. Proprioception (Active) Experiment.

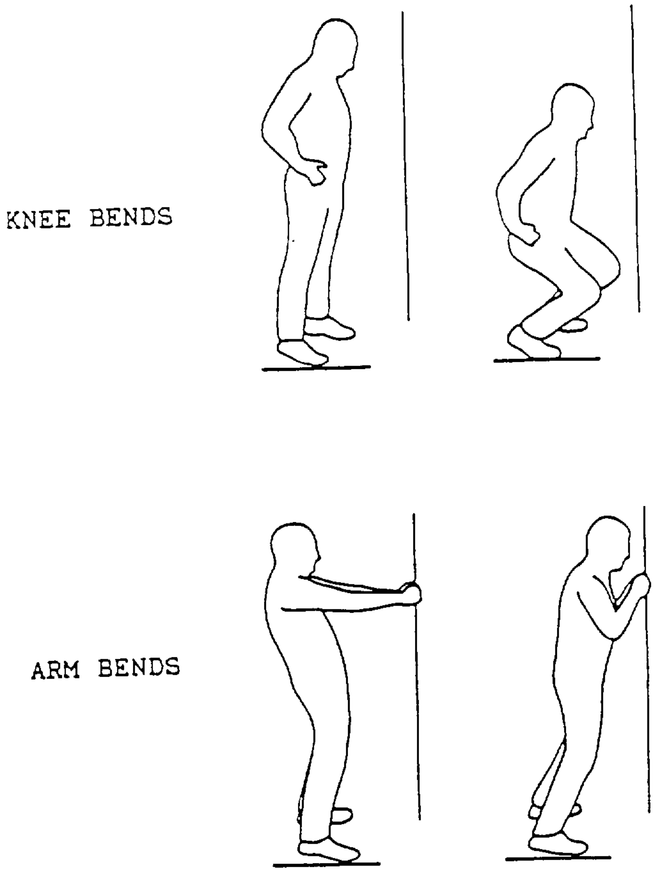

Figure 6. Proprioception (Illusions) Experiment.

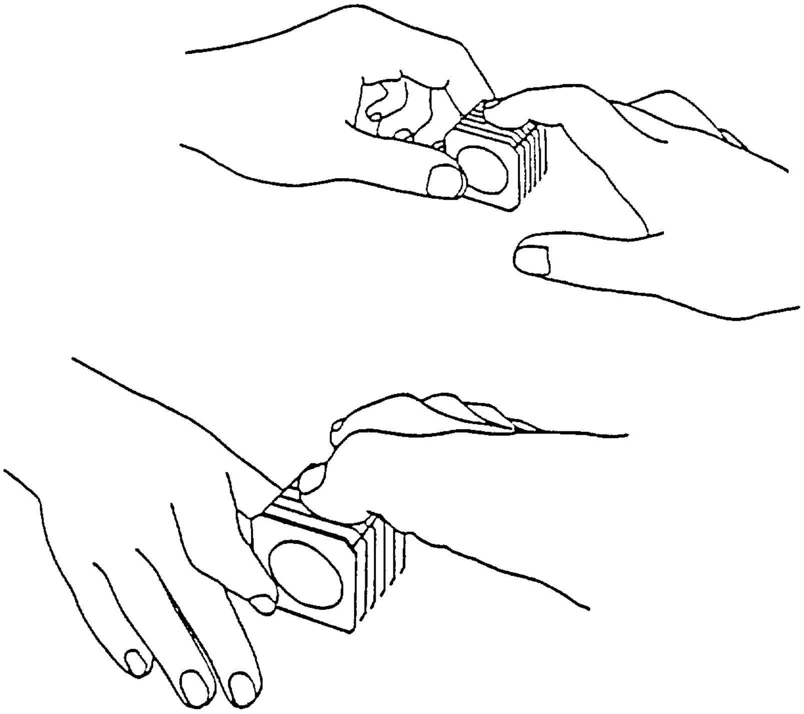

Figure 7. Tactile Acuity Experiment.