# Vision in the Space Environment

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## Author's Note

It must be noted that the subject discussed in this paper is not only one that is complex, but also one that is constantly changing. By the time a paper about the space environment reaches print, many of the ideas could well be obsolete.

This article was planned with the practising optometrist in mind. To compliment an extensive literature which already exists on the subject, only the ideas that it was felt would be of interest to, and act as primer on the subject for the interested practitioner are introduced here.

For further information on the subject, the author would refer readers to **Space Physiology and Medicine, NASA SP-447, US Government Printing Office, Washington, DC, USA**.

Man, living and working in the weightlessness of space, is an accomplished fact. The Soviets are committed to the establishment of a permanent space station from which they will attempt to reach other planets. The United States has also indicated that it will begin construction of a permanent space station. Therefore, man will have to learn how to survive in space for months, or even years, at a time.

Life in a zero gravity (zero-G) environment means that the human organism must adapt to the effective absence of gravity in order for the space traveller or worker to be able to accomplish successfully his or her daily tasks. The biomedical effects of weightlessness on the human organism will have to be extensively studied and, indeed, we are in the process of accumulating vast amounts of data on these effects. This paper will discuss some of these effects on the visual process and will enable optometrists to keep up with current developments in space that directly affect the visual process.

Vision, of all our senses, is the one most critical for orientation and adaptation to living and working in space. It is through vision that a person acquires primary points of reference in space, just as is the case here on Earth. For example, one of the astronauts noted that, during his initial hours in space, when he closed his eyes, his instinct was to "grab hold of whatever was nearest and just hang on, lest I fall."[9]

The visual environment in space is different from that on Earth. First, the brightness of objects under direct solar illumination is higher. On surfaces such as the moon, where there is no atmosphere, there is no scattering of light. Areas not under direct solar illumination appear much darker, due to the absence of diffused light and thus force a restructuring, because of darker shadows, of normal visual relationships.

This leads us to discuss one of the most dramatic conditions to arise during space flight, space motion sickness, which continues to plague astronauts. The neurovestibular reaction is still not well understood[10], but we do know that the visual process is involved[8]. One of the most plausible conclusions regarding its cause appears to be the "sensory conflict" hypothesis[3].

It is believed that the usual afferent visual and somatosensory inputs to the vestibular nuclei and other central mechanisms are no longer appropriate in the zero-G environment and that, somehow, the vestibulo-ocular reflex is altered. This results in aberrant reflex and effector responses. After a few days, the unfamiliar afferent sensory inputs are correctly interpreted. There is considerable evidence that, after a few days in space, the brain comes to rely even more on visual inputs.

Until we know exactly what causes space motion sickness, we will have to depend on such drugs as scopolamine — dextroamphetamine sulfate (dexedrine) or promethazine — ephedrine combinations[3].

Changes in body musculature are noted and disturbances of the motor regulation system are experienced during and after space flight. There is a decrease in total body mass, leg volume and muscular strength[3]. What interests us as optometrists is the decrease in visual motor task performance abilities[6]. Fortunately, this degradation is reversible after relatively short periods in space (1–14 days). We don't know yet if longer periods in space can cause irreversible damage, but this is highly unlikely. Will the astronauts be able to deal with an inflight emergency while suffering from the effects of motor disabilities? Future space travellers must acclimatize themselves and learn to adapt and function quickly as the changes occur.

As optometrists, we are aware that the sun's radiant energy has the potential to harm the eye. Recently, we have seen more and more articles in the optometric press concerning the adverse effects of sunlight on not only the body but also the eye. Solar radiation is being implicated as a causative agent ranging from pingueculae to various keratopathies.

The earth's atmosphere absorbs at least 15% of the visible radiation, but enough solar energy reaches the earth to harm the eye[11]. Astronauts, during daylight hours, work at a level of illumination about 1/4 higher than that on earth and, therefore, the risks are higher. Plastic spectacle lenses used in space will have attenuators in the plastic to filter out the ultraviolet radiation.

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Another hazard soon to be encountered in space is the laser beam. Military applications of lasers are increasing, for example in the areas of target ranging and illumination. Laser energy is capable of severely injuring any tissue in the eye that absorbs the beam energy.

Protective goggles or visors with an optical density that is considered safe at the laser wavelength will be employed. The current Extra Vehicular Visor assembly allows the astronaut to see out of the space suit. Multiple visors allow one to select the appropriate degree of protection from glare and ultraviolet radiation.

Visual acuity was tested during the Gemini 5 mission with an Inflight Vision Tester, because astronauts had reported acuity far above what had been expected. This is a binocular optical device containing a transilluminated array of high-and-low contrast rectangles. The astronaut judged the placement of each rectangle and indicated his response by punching holes in a record card. This was done pre-flight, in-flight, and post-flight.

The second part of the acuity measurement employed large rectangular patterns displayed at ground sites in Texas and Australia. The astronauts had to report the orientation of the rectangles. Displays were changed in orientation between passes and adjustments for size were made in accordance with anticipated slant range, solar elevation and the visual performance of the astronauts on preceding passes. Unfortunately, circumstances limited this test to only a couple of trials. The results were as follows: the visual performance of the astronauts neither improved nor worsened during the eight day mission[4]. Generally, visual acuity decreased slightly and there was a slight decrease in resolution. No change in lateral phorias and cyclophoria was noticed. There was a slight change in vertical phoria. All visual performance parameters returned to normal post-flight[4].

During the Apollo program, photographic studies of the retinal vasculature showed a significant decrease in the size of both veins and arteries about 3 1/2 hours after flight for one of the astronauts and a decrease in veins only for another astronaut after 4 hours[6]. The cause is still speculative and it is believed that the vasoconstrictive effect of oxygen alone could not account for the degree of constriction of the retinal vasculature. It is known that both blood volume and blood pressure, when the subject is in an upright posture, are low for the first few hours after returning from weightlessness.

There was also a post-flight decrease in intra-ocular tension in all cases[6]. Post-flight intra-ocular tension reverted to its preflight value at a slower rate than expected. The reason for the slow return to normal remains unknown. Also, noted was a post-flight decrease in the visual fields. Changes in colour vision were noted but not on a consistent basis.

Dark adapted crews in space flight reported light flashes with eyes either open or closed. Evidence shows that the flashes seen by astronauts can be correlated with charged particles transversing the retina. This was discovered when astronauts wore an electromechanical helmet-like device that supported cosmic radiation-sensitive emulsions. A direct physical record was made of cosmic ray particles that passed through the emulsion plates and the astronaut's head. The flux of these particles is sufficient to explain the entire phenomenon[7].

Obviously, much work remains to be done before some of the above space effects or anomalies will be understood. Some investigators[10] believe that much of the medical or physiological data accumulated to date has not only been improperly accumulated but also improperly interpreted. Unfortunately, there is so much work to be done on each flight, and so few flights, that some of the experimentation can only be done in a most cursory manner. Zero-G conditions will have to be produced on Earth in the laboratory to allow problems to be studied more easily, safely and less expensively.

The Soviets, who have spent more time in space than anyone else, have accumulated a little more data on visual system effects. At first, they felt that the brief exposure to the space environment caused no noticeable change in the basic functions of the visual system. They have since found that, during the first days of flight, the main visual functions (not fully explained) deteriorate by 5–30%, followed by a certain improvement of function until nearly normal[6].

Contrast sensitivity was subjected to the most pronounced change. There was a 10% loss immediately after entry into weightlessness which progressed to a 40% loss after five days[6]. The principal visual functions are only slightly affected under normal conditions of illumination. It appears then that vision in space is as reliable, after a short period of adaptation, as it is on earth. There are some changes in visual function but they appear to be small and the organism is able to adapt quickly.

Obviously, we have only begun to scratch the surface of research into man's physiological reactions to the weightlessness of space. Future flights will have to include vision specialists, who are sophisticated medical researchers, to carry out properly designed experiments on the eye's reaction and adaptation to weightlessness. A closer monitoring of the visual system will have to be done as man spends more time in space.

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