Image Cover Sheet

DISORIENTATION AND FLYING

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Disorientation and Flying

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Spatial disorientation (SD) in flight occurs when a pilot fails to sense or senses incorrectly the position, motion, or attitude of the aircraft within a fixed coordinate system. This coordinating system is provided by the surface of the Earth and the gravitational vertical. SD is a subset of situation awareness, which involves the correct appreciation of a large group of factors that are important in keeping the aircraft safe from hazardous situations.

The ability of humans to perceive orientation in three-dimensional space depends on the learned ability to interpret the continuous input of signals from the visual, vestibular, and somatosensory systems. The visual and vestibular systems play dominant roles in spatial orientation, and the somatosensory system generally supports those outputs derived from vestibular information processing. There are fundamental inadequacies and ambiguities in our sensory systems. For example, the semi-circular canals only detect angular acceleration, and once constant velocity is achieved, a blindfolded subject will feel motionless. The effect of a horizontal linear acceleration acting on the plane of the utricular otolith is indistinguishable from the effect of tilting the head through an angle whose sine value is equivalent to the magnitude of this linear acceleration.

Spatial disorientation should not be synonymous with vestibular or visual illusions alone. It is also the behavioural responses and the cognitive integration of all of these sensory inputs. The responses to the physical and mental load imposed by the increasingly demanding flying task must also be considered. The etiology of some typical visual and vestibular illusions has been known for decades. However, the role of cognitive phenomena, such as selective attention, expectancy, and supra arousal effect, in pilots' failure to make optimum use of available information about the aircraft's orientation is poorly understood. The etiology of spatial disorientation could be classified under two headings, which are not mutually exclusive:

- SD resulting from erroneous or inadequate sensory information being transmitted to the central nervous system; and
- SD resulting from erroneous or inadequate perception of the correct sensory information received.

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SD and GLOC (G-induced loss of consciousness) are at the top of aviation safety issues. Spatial disorientation is a more difficult problem to solve as it involves the complexity of a multiple, interactive, perceptual process, while GLOC is primarily a problem of cardiovascular hydraulics. The environment and conditions in which SD is likely to be exposed to SD is much higher. In the Canadian Forces, spatial disorientation in flight contributes significantly to aircraft accidents and incidents. A recent study (Cheung et al., 1995) suggests that SD played at least a contributing role in 14 of 62 fatal accidents (23%). Of the SD accidents, 11 involved a total loss of 24 lives. All but two of the accidents fell into the category of unrecognized SD where the pilot was unaware of the disorientation.

The current approaches to solving SD problems include: research on the underlying mechanism of spatial disorientation; and investigation into an effective spatial orientation training program. One of our concerns is that pilots receive adequate and correct visual information. The Vestibulo-Ocular Reflex (VOR) stabilizes binocular fixation on visual targets during head movements, thereby maintaining a stable foveal image. Traditionally, the VOR referred to the eye movement in response to head rotation as a canal-mediated effect. Most natural head movements are a combination of linear and angular stimuli. It is important to understand how these two distinct components of the vestibular system interact centrally to produce appropriate eye movements. The translational VOR (tVOR) in response to linear acceleration was believed to be negligible in humans until recently, when it was shown that the response sensitivity of this reflex varies inversely with the target distance. Such considerations are particularly important for pilots due to the large translational accelerations experienced during flight. Pilots must regularly change their fixation distance from distant targets to nearby ones (instrument panel, HUD, etc.). Since the nearby targets are moving with the head, any eye movements generated by the tVOR would be inappropriate. Failure to suppress such unwanted tVOR responses could be expected to result in blurred vision and disorientation. Studies are being conducted to study the normal range of such behaviour.

The traditional spatial orientation training program involves primarily didactic lectures, accident briefings, and demonstrations on the Barany chair. However, there are pilots who believe that SD is not a serious problem or that they are not susceptible. Hands-on experience under SD simulation will elucidate one's limitations and capabilities. Familiarity with the helpless and frightening situation that can occur under SD simulation will provide pilots with the knowledge of how to interpret sensory inputs under similar situations in flight. This experience could shorten the time between unrecognized and recognized SD and improve one's ability to handle the situation.

Over the years a number of devices have been produced for use in spatial disorientation training. These devices range from the Barany chair, to centrifuges having a gimbaled gondola with three degrees-of-freedom and complete cockpit instrumentation and controls. Personal experience with a disorientation training or familiarization device should help to dispel the "but not me" attitude and enable trainees to discover for themselves that their sensory system has the same limitations and is as susceptible to illusory perceptions as their colleagues'. However, there is no evidence that modern spatial disorientation training devices influence SD accident rates. If loss of aircraft control during disorientation occurs because of poor pilot proficiency while in a disoriented state, exact replication of airborne disorienting stimuli may be unnecessary to achieve effective training. Currently, we are investigating the feasibility of using visual-only stimuli to simulate disorientation and to evaluate subjects' reactions to disorientation by their success in maintaining a prescribed subjective vertical (or any prescribed parameter that the pilot is instructed to maintain). With continuous support, a more progressive attitude toward research and development in spatial disorientation, and training in spatial orientation, we believe that a positive impact could be made. ✦

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