

Aviation safety - could mild hypoxia impair complex flight decisions?

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1. Introduction

Reduced oxygen levels (mild hypoxia) in aircrew, due to reduced cabin pressure - equivalent to an altitude of 8000ft in most commercial aircraft or up to 12,000ft in some military aircraft, could impair their complex cognition, including decision-making, and mood (see references). This could be a latent safety hazard for most routine flights, particularly when aircrew may have subtle and complex decisions to make whilst faced with high workloads in novel, difficult or emergency situations. The present study was designed to explore the effects of mild hypoxia on complex cognition and mood using a battery of psychological tests that drew on some of the complex cognitive capacities, including decision-making, that are common in a wide variety of real-world situations by pilots. We hypothesized that some of the cognitive tests selected for the study would be affected by altitude on account of their complexity and novelty and because they involved multiple demands. The study also explored the efficacy of a potential practical 'simple fix' (i.e. the use of supplementary oxygen) in which it was hypothesized that cognition and mood would be restored to normal levels.

2. Methods

Thirty six volunteer airforce personnel were sequentially exposed in a randomized balanced order in a hypobaric chamber in three runs each comprising approximately 30 minutes of exposure to each of baseline (sea level), a specified altitude (equivalent to sea level, 8000ft and 12,000ft), and followed immediately by breathing 100% oxygen from an oro-nasal mask. In each run for each exposure, complex cognition and mood were assessed (after 4 prior practices) using tests for memory search, processing speed (Stroop test), mathematical processing, 3-dimensional spatial rotation (Manikin test), logical relations, decision-making/mental flexibility (Tower puzzle test) and the profile of mood states for vigor, anxiety, depression, fatigue, happiness, restlessness and anger. Analysis of variance was used to examine the effects on test performance of Condition and Altitude (where 0=ground level, 8=8000ft, 12=12,000ft). A statistically significant interaction term for Condition*Altitude was indicative of reduced performance or mood due to differences between conditions and altitude.

3. Results

*Table 1. Mean scores for the three tests of cognition and mood for which there was a statistically significant effect for Condition*Altitude interaction*

	Condition (0=sea level, 8=8000ft, 12=12,000ft)	Baseline (at sea level)	At specified Altitude	At specified Altitude with supplementary oxygen
Logical relations	0	33.7	37.1	33.8
	8	34.5	32.9	33.0
	12	34.2	33.1	31.5
Fatigue	0	0.7	0.9	0.8
	8	0.8	0.8	0.8
	12	0.7	1.3	1.1
Vigor	0	2.5	2.3	2.3
	8	2.5	2.3	2.2
	12	2.4	2.0	2.3

The only tests of cognition or mood for which there were any statistically significant effects for Condition*Altitude, were logical relations ($F=2.92$, $p=0.023$), fatigue ($F= 5.05$, $p=0.001$) and vigor ($F=2.67$, $p=0.035$). Mean data are shown in Table 1. Although the effects were significant for logical relations, this may have been due to an unexpectedly high value (37.1) during the ‘altitude’ exposure at sea level. Alternatively an improvement due to practice from baseline to the ‘specified altitude’ may have occurred but was negated by hypoxia at 8000ft and 12,000ft. With supplementary oxygen, performance may have fallen, perhaps because of the effect of the mask and/or time-related fatigue. Although the value of 37.1 for the sea level ‘altitude condition might be unexpected, the finding is consistent with an effect of mild hypoxia on logical relations. Feelings of fatigue and vigor remained the same at 8000ft but fatigue was increased and vigor reduced at 12,000ft and was restored by supplementary oxygen. In general, the analysis failed to support the view that complex cognition is impaired by mild hypoxia but that logical relations may have been influenced. The practical significance of these findings are that one aspect of complex cognition - logical relations - may be impaired at 12,000ft and aircrew may feel more fatigued and less vigorous at 12,000ft which can be restored by supplementary oxygen.

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