Time Course to Recovery of Cerebral Blood Oxygen Saturation Following an Acute Hypoxic Event

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Hypoxia–induced loss of consciousness has been implicated in a substantial number of mishaps involving the loss of planes and aircrew.

- The problem is more common in the current generation of planes (OBOGS).

Of critical concern is a more complete understanding of the specific performance impairments of hypoxia, and the degree to which underlying function is...
It has been assumed that performance effects stemming from hypoxia are alleviated within minutes of returning to sea-level oxygen concentrations.

Previous research has shown residual performance deficits following hypoxic events:
- Consequently, aircrews could be significantly impaired for flight.
1. Establish the effects of hypoxia on Simple and Choice Reaction Time (SRT/CRT) Tasks
   ◦ Determine the length of time necessary for performance on these tasks to return to pre-exposure levels

1. Establish the effects of hypoxia on cerebral oxygen saturation (rSO$_2$) levels
   ◦ Record the amount of time required for rSO$_2$ to return to baseline levels
Method / Equipment

**Reduced Oxygen Breathing Device (ROBD)**

Uses Thermal Mass Flow Controllers to combine breathing air and nitrogen to produce the equivalent atmospheric oxygen content for altitudes up to 34,000 ft.

**Simple/Choice Reaction Time (SRT/CRT) Task**

The SRT/CRT Task was designed to measure response speed to visual targets where stimuli were either predictable (simple reaction time) or unpredictable (choice reaction time).

**Near-Infrared Spectroscopy (NIRS)**

The Somanetics INVOS Cerebral/Somatic Oximeter monitors regional oxygen saturation ($rSO_2$) of the frontal lobe.
19 participants attended three visits and completed all stages of the study.

**Visit 1**
- SRT/CRT administered three times
- rSO$_2$ recorded during task
- Performance and physiological indices were averaged separately into Trial Block 1
Procedure

Visit 2

- Exposure
  - 18,000 ft simulated altitude exposure for 30 minutes
  - Repeat Visit 1 procedures – data averaged as Trial Block 2

- Immediately post-exposure
  - Sea-level air concentration administered for 30 minutes
  - Repeat Visit 1 procedures – data averaged as Trial Block 3

- 60 min post-exposure
  - Repeat Visit 1 procedures – data averaged as Trial Block 4

- 120 min post-exposure
  - Repeat Visit 1 procedures – data averaged as Trial Block 5
Visit 3

- Participants return to testing site 24 hours after hypoxic exposure
- SRT/CRT administered a final three times and rSO$_2$ recorded during task
- Performance and physiological indices were averaged separately into Trial Block 6
Performance Efficiency

Response Time (in ms)

Simple Response Time
Choice Response Time

Trial Block

1 2 3 4 5 6
Participants’ resting rSO₂ baselines were recorded prior to the start of the task during Visit 1
   - Deviations from the resting baseline were expressed as a proportion of that baseline value
$r\text{SO}_2$

Oxygen Saturation Relative to Baseline

Trial Block
Purpose of the present study was to examine the role of hypoxia in terms of its effects on performance as measured by the SRT/CRT Task and rSO$_2$ levels

- **Response Time**
  - Slowing of response time during Trial Block 2
  - Did not recover completely until 24 hours post-exposure
  - Trends of recovery during Trial Blocks 4 and 5, but was not sustained
NIRS Data

- Results were similar to those found with the SRT/CRT Task
- rSO$_2$ declined sharply during Trial Block 2, and did not return to baseline values until 24 hours after hypoxic exposure
- The relationship between performance and rSO$_2$ levels remains largely unknown
Discussion

- Latency in recovery of rSO$_2$ and performance is possibly associated with spreading depression caused by axonal depolarization.

- Operating a modern tactical air platform requires an extremely high level of performance:
  - Following a hypoxic episode, it is likely that performance is compromised for an extended period of time.

- Future research should be focused on mitigation and prevention efforts rather than training operators to recognize and react to hypoxic symptomology.
Questions
References

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- Deussing, E., Artino, A., & Folga, R. (2011). In-flight hypoxia events in tactical jet aviation: Characteristics compared to normobaric training. *Aviation, Space, and Environmental Medicine, 82,* 775–781.