Mass Controller System for Hypoxia and Hyperoxia Testing

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Abstract

Mass flow controllers are used to regulate the flow of gas through chambers, thus controlling the concentrations of gas in an enclosed chamber. A system was designed to test the effects of different concentrations of O_2 and N_2, within mice. The system has three main variables as outlined by the client: software, mass flow controllers, and interface for communication. A plethora of research has been completed on different types of mass flow controllers, mass flow controller manufacturers, and different types of communication interfaces. A LabView software

program has been designed to control hypoxia and hyperoxia testing, and is the alpha stage of testing.

Problem Statement

The purpose of this project is to design a system that can create a reproducible and accurate hypoxic/hyperoxic environment with the capability of oscillating between various concentrations of oxygen and nitrogen.

Client Motivation

Our client, Brad Hodgeman, has the following motivations:

1) Determine the physiological mechanism of neural respiratory plasticity. It is widely believed that neural plasticity is dependent on serotonin 5HT, but the whole mechanism is yet to be discovered.
2) Purchase new mass flow controllers and develop user-friendly software. The current mass flow controllers are inaccurate and the software is outdated
3) Increase the automation of the system. Currently, there are manual aspects of the system that the client would like to eliminate in order to increase efficiency within the system.

Hypoxia Background

The neural respiratory control system's responses to respiratory stresses such as intermittent & continuous hypoxia along with hyperoxia are being associated to clinical disorders such as sudden infant death syndrome (SIDS), apnic sleep disorders, and spinal cord injury.

Links between these (and other) clinical disorders and hypoxia/hyperoxia are being investigated by researchers in hopes of finding the mechanisms behind their correlations.

Normal respiration includes ~21% atmospheric O_2, ~78% N_2, and a very small percentage of all other gases. A lack of inspired O_2 (<21%) can cause a condition called hypoxia, where insufficient amounts of O_2 reach the tissues of an organism. Induced hypoxic conditions are more extreme but analogous to atmospheric oxygen at high altitudes (Fig. 1). The physiological and morphological effects from hypoxia can be detrimental to the organism if the O_2 level is down low enough and is induced for long enough periods of time.

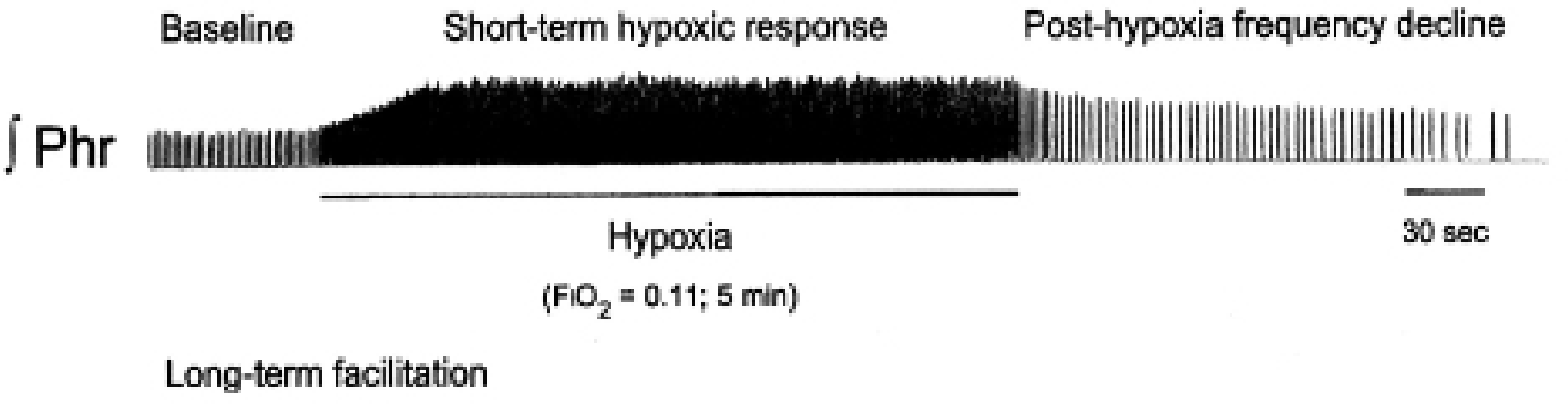

Figure 1. Phrenic response to Short-term hypoxia. The steady decline in phrenic response following the short-term hypoxic response, exhibits no long term facilitation (LTF) induced from continuous hypoxia. (From Kinkead *et al*, 1998)

Developmental respiratory control in many mammalian species can be heavily influenced by variation in gas concentrations (Johnson and Mitchell, 2003). Hyperoxia is a condition of ambient O_2 levels being above the standard (low altitude) atmospheric O_2 levels of 21%. Animal models support the conclusion that perinatal changes in O_2 levels induce developmental plasticity: lasting changes in the respiratory control system that can be drawn out only during