Carbon Dioxide: Surprising Effects on Decision Making and Neurocognitive Performance

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The occupants of modern submarines and the International Space Station (ISS) have much in common as far as their air quality is concerned. Air is polluted by materials offgassing, use of utility compounds, leaks of systems chemicals, and anthropogenic sources. The primary anthropogenic compound of concern to submariners and astronauts has been carbon dioxide (CO_2). NASA and the US Navy rely on the National Research Council Committee on Toxicology (NRC-COT) to help formulate exposure levels to CO_2 that are thought to be safe for exposures of 3-6 months. NASA calls its limits Spacecraft Maximum Allowable Concentrations (SMACs). Years of experience aboard the ISS and a recent publication on deficits in decision making in ground-based subjects exposed briefly to 0.25% CO_2 suggest that exposure levels that have been presumed acceptable to preserve health and performance need to be reevaluated.

The current CO_2 exposure limits for 3-6 months set by NASA and the UK Navy are 0.7%, and the limit for US submariners is 0.5%, although the NRC-COT recommended a 90-day level of 0.8% as safe a few years ago. NASA has set a 1000-day SMAC at 0.5% for exploration-class missions. Anecdotal experience with ISS operations approaching the current 180-day SMAC of 0.7% suggest that this limit is too high. Temporarily, NASA has limited exposures to 0.5% until further peer-reviewed data become available. In the meantime, a study published last year in the journal *Environmental Health Perspectives* (Satish U, et al. 2012) demonstrated that complex-decision-making performance is somewhat affected at 0.1% CO_2 and becomes “dysfunctional” for at least half of the 9 indices of performance at concentrations approaching 0.25% CO_2. The investigators used the Strategic Management Simulation (SMS) method of testing for decision-making ability, and the results were so surprising to the investigators that they declared that their findings need to be independently confirmed.

NASA has responded to the findings on decision making by developing a study to either confirm or refute the published results. In addition, other neurocognitive tests that have been and will be used aboard the ISS will be part of the ground-based study. Further evaluations during the exposures will include ocular and cardiovascular effects of CO_2 exposure. In addition, the 1-carbon genetics of the test subjects will be evaluated to determine if any individual subjects are unusually susceptible to CO_2 exposure because of genetic factors. Our plan is to extend the published study from Satish by employing a wider series of CO_2 exposures to include concentrations of 0.06, 0.12, 0.25, and 0.50%. We believe that our findings will be of keen interest to submariners and to those designing “tight” buildings.