Impact of CO_2 on human decision making and productivity

Usha Satish[1,*], William B. Fisk[2], Mark J. Mendell[2], Katia Eliseeva[2], Toshifumi Hotchi[2], Douglas Sullivan[2], Lisa B. Cleckner[3], Krishnamurthy Shekhar[1] and Kaeling Teng[1]

[1]SUNY Upstate Medical University, Syracuse, NY
[2]Lawrence Berkeley National Laboratories, Berkeley, CA
[3]Syracuse Center of Excellence, Syracuse, NY

[*]*Corresponding email: satishu@upstate.edu*

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1 Introduction

Significant economic savings and productivity gains in worker performance are estimated even with a small improvement in indoor environmental quality (Fisk, 2000). Real-world productivity is based on environmental conditions that are volatile, complex, and ambiguous with uncertainty and delayed feedback. Therefore, the measurement tool needs to capture functioning as it happens in the real-world. The Strategic Management Simulations (SMS) methodology has been designed to measure the process of thinking and has been widely used in many industries to assess cognitive and behavioral responses to real-world task situations (Satish and Streufert, 1997).

2 Materials/Methods

For more than forty years, the applicability of SMS simulations as a predictor of human performance and productivity in the real-world settings have been demonstrated with high levels of predictive validity and reliability across different professions, different cultures and in different continents (Satish and Streufert, 1997; Breur and Streufert, 1995; Streufert et al., 1988; Streufert and Swezey, 1986). Overall concurrent and predictive validity coefficients consistently exceed r=+.60. Reliability values range from r=+0.7 to r=+0.94 (Streufert et al., 1988). The methodology has been used to study the effects of beta-blockers, alcohol, caffeine, marijuana, tranquilizers (Streufert, et al., 1993; Streufert, et al., 1997; Satish and Streufert, 2003). The SMS tool is highly sensitive to small differences in drug or environmental influences upon human functioning with real-world relevance (Streufert, et al., 1996; Streufert and Satish, 2005).

Participants are exposed to real –world scenarios on a computer screen. They respond to real-world situations and make decisions. Based on their actions, computer calculated and scored measurement profiles are generated for 25 validated characteristics of human functioning.

22 adults between the ages of 18 and 35 years participated in a randomized within subjects study design. The decision-making abilities of the study participants were assessed under three different and well characterized conditions - 600ppm, 1000ppm and 2500 ppm of CO_2 exposure. CO_2 levels were monitored continuously during all the conditions. All other conditions including the ventilation rate were kept constant.

3 Results

Performance of 22 subjects on nine simulation measures was compared in a within subjects design across three treatment conditions (600ppm, 1000ppm and 2500ppm of CO_2 exposure) that were presented in counterbalanced order. Table 1 shows the comparison of performance variables across the three treatment conditions.

While performance in most cases decreased from treatment level 1 to 2 and even more (often at a greater level) from treatment level 2 to 3, no differences among treatment were obtained for comparisons of treatment levels 1 and 2 for initiative, but treatment level 3 differed significantly from the other two treatments. The inverse finding was obtained for focused activity. While again no differences were obtained for comparisons of treatment conditions 1 and 2, performance under conditions 3 *exceeded* performance during the other two treatments. No differences among any of the three treatment levels were obtained for information search.

Table 1. Comparison of Treatments

	COMPARISONS OF TREATMENTS Condition 1 – 600 ppm of CO_2 exposure Condition 2 – 1000 ppm of CO_2 exposure Condition 3 – 2500 ppm of CO_2 exposure					
Variables	**1 vs 2**	**1/21 df**	**1 vs 3**	**1/21 df**	**2 vs 3**	**1/21 df**
	Direction	**Prob**	**Direction**	**Prob**	**Direction**	**Prob**
Basic Activity	1>2	p<.01	1>3	p<.01	2>3	p<.01
Applied Activity	1>2	p<.01	1>3	p<.01	2>3	p<.01
Focused Activity		NS	1<3	p<.01	2<3	p<.01
Task Orientation	1>2	p<.05	1>3	p<.01	2>3	p<.01
Initiative	marginal1>2	p<.10	1>3	p<.01	2>3	p<.01
Information Search	1>2	NS		NS		NS
Information Usage	1>2	p<.01	1>3	p<.01	2>3	p<.01
Breadth of Approach	1>2	p<.01	1>3	p<.01	2>3	p<.01
Strategy	1>2	p<.05	1>3	p<.01	2>3	p<.01

4 Conclusions

The performance or decision making is at marginal or even at dysfunctional level on some of the important productivity measures, especially at 2500 ppm – a typical concentration found in many buildings. The difference between 400 and 1000 ppm though less is still significant. This impact may dictate minimum required ventilation rates per person and consequently the potential to achieve energy savings may be constrained by the direct effects of CO_2 on people.

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