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Rising carbon dioxide causes more than a climate crisis -- it may directly harm our ability to think

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Summary: New research finds that an anticipated rise in carbon dioxide concentrations in our indoor living and working spaces by the year 2100 could lead to impaired human cognition.

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Carbon dioxide in air concept illustration (stock image).

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As the 21st century progresses, rising atmospheric carbon dioxide (CO_2) concentrations will cause urban and indoor levels of the gas to increase, and that may significantly reduce our basic decision-making ability and complex strategic thinking, according to a new CU Boulder-led study. By the end of the century, people could be exposed to indoor CO_2 levels up to 1400 parts per million -- more than three times today's outdoor levels, and well beyond what humans have ever experienced.

"It's amazing how high CO_2 levels get in enclosed spaces," said Kris Karnauskas, CIRES Fellow, associate professor at CU Boulder and lead author of the new study published today in the AGU journal *GeoHealth*. "It affects everybody -- from little kids packed into classrooms to scientists, business people and decision makers to regular folks in their houses and apartments."

Shelly Miller, professor in CU Boulder's school of engineering and coauthor adds that "building ventilation typically modulates CO_2 levels in buildings, but there are situations when there are too many people and not enough fresh air to dilute the CO_2." CO_2 can also build up in poorly ventilated spaces over longer periods of time, such as overnight while sleeping in bedrooms, she said.

Put simply, when we breathe air with high CO_2 levels, the CO_2 levels in our blood rise, reducing the amount of oxygen that reaches our brains. Studies show that this can increase sleepiness and anxiety, and impair cognitive function.

We all know the feeling: Sit too long in a stuffy, crowded lecture hall or conference room and many of us begin to feel drowsy or dull. In general, CO_2 concentrations are higher indoors than outdoors, the authors wrote. And outdoor CO_2 in urban areas is higher than in pristine locations. The CO_2 concentrations in buildings are a result of both the gas that is otherwise in equilibrium with the outdoors, but also the CO_2 generated by building occupants as they exhale.

Atmospheric CO_2 levels have been rising since the Industrial Revolution, reaching a 414 ppm peak at NOAA's Mauna Loa Observatory in Hawaii in 2019. In the ongoing scenario in which people on Earth do not reduce greenhouse gas emissions, the Intergovernmental Panel on Climate Change predicts outdoor CO_2 levels could climb to 930 ppm by 2100. And urban areas typically have around 100 ppm CO_2 higher than this background.

Karnauskas and his colleagues developed a comprehensive approach that considers predicted future outdoor CO_2 concentrations and the impact of localized urban emissions, a model of the relationship between indoor and outdoor CO_2 levels and the impact on human cognition. They found that if the outdoor CO_2 concentrations do rise to 930 ppm, that would nudge the indoor concentrations to a harmful level of 1400 ppm.

"At this level, some studies have demonstrated compelling evidence for significant cognitive impairment," said Anna Schapiro, assistant professor of psychology at the University of Pennsylvania and a coauthor on the study. "Though the literature contains some conflicting findings and much more research is needed, it appears that high level cognitive domains like decision-making and planning are especially susceptible to increasing CO_2 concentrations."

In fact, at 1400 ppm, CO_2 concentrations may cut our basic decision-making ability by 25 percent, and complex strategic thinking by around 50 percent, the authors found.

The cognitive impacts of rising CO_2 levels represent what scientists call a "direct" effect of the gas' concentration, much like ocean acidification. In both cases, elevated CO_2 itself -- not the subsequent warming it also causes -- is what triggers harm.

The team says there may be ways to adapt to higher indoor CO_2 levels, but the best way to prevent levels from reaching harmful levels is to reduce fossil fuel emissions. This would require globally adopted mitigation strategies such as those set forth by the Paris Agreement of the United Nations Framework Convention on Climate Change.

Karnauskas and his coauthors hope these findings will spark further research on 'hidden' impacts of climate change such as that on cognition. "This is a complex problem, and our study is at the beginning. It's not just a matter of predicting global (outdoor) CO_2 levels," he said. "It's going from the global background emissions, to concentrations in the urban environment, to the indoor concentrations, and finally the resulting human impact. We need even broader, interdisciplinary teams of researchers to explore this: investigating each step in our own silos will not be enough."

Authors of "Fossil fuel combustion is driving indoor CO_2 toward levels harmful to human cognition," published in AGU's *GeoHealth* today, are Kristopher B. Karnauskas (CIRES, CU Boulder Atmospheric and Oceanic Sciences and Colorado School of Public Health), Shelly L. Miller (Mechanical Engineering, CU Boulder), and Anna C. Schapiro (Psychology, University of Pennsylvania).

Story Source:

Materials provided by **University of Colorado at Boulder**. *Note: Content may be edited for style and length.*

Journal Reference:

1. Kristopher B. Karnauskas, Shelly L. Miller, Anna C. Schapiro. **Fossil fuel combustion is driving indoor CO_2 toward levels harmful to human cognition**. *GeoHealth*, 2020; DOI: 10.1029/2019GH000237

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