

Rising CO₂ causes more than a climate crisis—it may directly harm our ability to think

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As the 21st century progresses, rising atmospheric carbon dioxide (CO₂) 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 CO₂ 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 CO₂ 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 CO₂ levels in buildings, but there are situations when there are too many people and not enough fresh air to dilute the CO₂." CO₂ 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 CO₂ levels, the CO₂ 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, CO₂ concentrations are higher indoors than outdoors, the authors wrote. And outdoor CO₂ in [urban areas](#) is higher than in pristine locations. The CO₂ concentrations in buildings are a result of both the gas that is otherwise in equilibrium with the outdoors, but also the CO₂ generated by building occupants as they exhale.

Atmospheric CO₂ 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 CO₂ levels could climb to 930 ppm by 2100. And urban areas typically have around 100 ppm CO₂ higher than this background.

Karnauskas and his colleagues developed a comprehensive approach that considers predicted future outdoor CO₂ concentrations and the impact of localized urban emissions, a model of the relationship between indoor and outdoor CO₂ levels and the impact on human cognition. They found that if the outdoor CO₂ 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 CO₂ concentrations."

In fact, at 1400 ppm, CO₂ 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 CO₂ levels represent what scientists call a "direct" effect of the gas' concentration, much like ocean acidification. In both cases, elevated CO₂ itself—not the subsequent warming it also causes—is what triggers harm.

The team says there may be ways to adapt to higher indoor CO₂ 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) CO₂ 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."

More information: Kristopher B. Karnauskas et al, Fossil fuel combustion is driving indoor CO₂ toward levels harmful to human cognition, *GeoHealth* (2020). [DOI: 10.1029/2019GH000237](https://doi.org/10.1029/2019GH000237)

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