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Public Perceptions of How Long Air Pollution and Carbon Dioxide Remain in the Atmosphere

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The atmospheric residence time of carbon dioxide is hundreds of years, many orders of magnitude longer than that of common air pollution, which is typically hours to a few days. However, randomly selected respondents in a mail survey in Allegheny County, PA ($N = 119$) and in a national survey conducted with MTurk ($N = 1{,}013$) judged the two to be identical (in decades), considerably overestimating the residence time of air pollution and drastically underestimating that of carbon dioxide. Moreover, while many respondents believed that action is needed today to avoid climate change (regardless of cause), roughly a quarter held the view that if climate change is real and serious, we will be able to stop it in the future when it happens, just as we did with common air pollution. In addition to assessing respondents' understanding of how long carbon dioxide and common air pollution stay in the atmosphere, we also explored the extent to which people correctly identified causes of climate change and how their beliefs affect support for action. With climate change at the forefront of politics and mainstream media, informing discussions of policy is increasingly important. Confusion about the causes and consequences of climate change, and especially about carbon dioxide's long atmospheric residence time, could have profound implications for sustained support of policies to achieve reductions in carbon dioxide emissions and other greenhouse gases.

KEY WORDS: Air pollution; atmospheric residence time; carbon dioxide

1. INTRODUCTION

Experts in the geophysics community have understood the role of greenhouse gases in shaping the earth's climate for over a century.[1,2] In the latter half of the 20th century, they grew increasingly confident and concerned about the risks of climate change.[3] Despite scientific consensus on the need to dramatically reduce greenhouse gas emissions now, political discourse and media coverage have grown ever more confusing and contentious.[4] This may be attributed, at least in part, to intentional efforts to keep people confused.[5]

Studies conducted since the early 1990s have observed a number of changes in public understanding of the causes of climate change.[6–9] Other studies have explored how perceptions of climate change are related to knowledge, cultural, and political orientation, among other factors.[10–24] While a majority of Americans believe that climate change is real, they do not fully understand its causes. Past communication efforts have been developed to address many of these misconceptions and to promote a more complete scientific understanding.[25–27]

In our view, public understanding of two facts is an essential ingredient to informed public discourse about climate change:

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(1) The primary cause of climate change is carbon dioxide that is added to the atmosphere when coal, oil, and natural gas are burned; and
(2) Unlike conventional air pollutants[4]—defined here as pollutants like smog, oxides of sulfur and nitrogen, organic gases, and fine particles—which remain in the atmosphere for only a few hours or days, once carbon dioxide enters the atmosphere, much of it remains there for hundreds of years.

Although the literature on public understanding demonstrates that considerable progress has been made on the first of these points,[9] the literature on public understanding is largely silent on the second. One study that did address this found that a third of Americans thought ceasing carbon dioxide emissions would cause an immediate decrease in carbon dioxide concentrations in the atmosphere, and when asked, "On average, how long does carbon dioxide stay in the atmosphere once it has been emitted?" two-thirds responded that they did not know.[15] Another study found that people who hold a pollution mental model often blame environmental harms, like air pollution from toxic chemicals, for changes in the climate.[10] As a result, people may falsely conclude that if climate change is real and gets serious enough, it can be fixed relatively quickly by cutting emissions, just as was done with air pollution.

Once it enters the atmosphere, air pollution is quickly removed by a number of natural processes.[28] This is not true for carbon dioxide. When carbon dioxide is added to the atmosphere, some of it is absorbed by the oceans or is taken up by plants, but much of what is left stays in the atmosphere for hundreds of years, since there are no other natural processes that quickly remove it.[29] Indeed, some of the carbon dioxide in the atmosphere today is the result of burning coal in British factories during the Industrial Revolution.

To the extent that there is public confusion about the difference between common air pollution and carbon dioxide (as well as other long-lived greenhouse gases), it may be exacerbated by advocates and policymakers who refer to carbon dioxide as "pollution"—perhaps to gain initial momentum toward combating climate change. For example, the U.S. Supreme Court ruled that the Environmental Protection Agency (EPA) has authority to regulate emissions of carbon dioxide as an "air pollutant" under the Clean Air Act.[30,31] More recently, the Obama Administration's Clean Power Plan leveraged support for reducing carbon dioxide emissions by presenting them as an air pollutant.

In this article, we explore the extent to which Americans understand the fundamental difference in atmospheric residence time between common air pollutants and carbon dioxide. We also examine beliefs about causes of climate change and how these views influence willingness to take action against climate change. We ask:

(1) To what extent do people understand the difference in atmospheric residence times between common air pollution and carbon dioxide, as well as the sources of each?
(2) To what extent do people correctly identify causes of climate change?
(3) To what extent do these beliefs affect people's support to take action against future serious changes in the climate?

2. METHOD

2.1. Survey Procedure

We administered a mail survey in Allegheny County, Pennsylvania (PA), USA, and a national online survey with Mechanical Turk (MTurk).[32] We extend the efforts of previous research that has documented public understanding of climate change and its surrounding issues in Pittsburgh, PA.[7–9] Two parallel questions were included in a related national survey, for comparison. We employed a mail survey because many people do not have easy access to the Internet. For example, almost 1 million PA residents lack Internet entirely.[33] Even if they have access, many elderly people, and people who are very busy, do not participate in online surveys.[34] Rookey *et al.*[35] report that mail studies may "improve the overall accuracy of survey results." The mail survey did include instructions on how to complete the same survey online, if desired (but none of the PA participants chose this response method).

2.1.1. Mail Survey

The mail survey covered four topics: (1) source and atmospheric residence time of common air pollution (3 items); (2) source and atmospheric residence

[4]By "conventional" and "common," we refer to short-lived air pollutants but do not intend to imply that anthropogenic CO2 emissions are less conventional or common than other anthropogenic emissions.

time of carbon dioxide (4 items); (3) basic facts about electricity production in the United States (6 items); and (4) causes of and responsibility for climate change and what, if anything, can and ought to be done about it (11 items). A number of the questions adopted wording from our previous studies on public understanding of climate change.[7–9] Other questions were pretested in a small study using randomly distributed mail-back postcards.

The order of questions about air pollution and carbon dioxide was reversed in half of the mail surveys. No order effects were found ($p > 0.05$). Demographic questions (educational attainment, income, age, gender, political affiliation, and religion) were placed at the end of the survey so as to not influence responses.

The section on "common air pollution" began by defining the term as "pollutants like smog, oxides of sulfur and nitrogen, organic gases and fine particles." It asked respondents to rank order (1–4) four sources of common air pollution in their region in terms of their "best guess of how much each contributes to air pollution in the region where you live:" (1) all kinds of industry and factories; (2) power plants making electricity; (3) residential and commercial sources (for example, furnaces and water heaters in homes, stores, and office buildings); and (4) all kinds of transportation (airplanes, cars, trains, trucks, ships, etc.). Subsequent questions asked if less than a few percent of common air pollution here in the United States comes from thousands of miles away (answered on a five-point degree of belief scale comprising "true," "probably true," "don't know," "probably false," and "false"; abbreviated T, ~T, ?, ~F, and F in subsequent sections).

A "don't know" option was included to cue participants that having no information would be an acceptable response.[36] The final question about common air pollution read: "Imagine that the world's modern factories, transportation and power plants all stopped emitting **common air pollution** now. How long would it take for the amount of pollution in the air to fall back to what it was before those modern factories, transportation and power plants existed?" Respondents answered using a six-point scale, ranging from "hours to days" to "never."

Questions about carbon dioxide followed a parallel structure. Participants were first asked to assign 100 points across five sources to estimate "where the carbon dioxide (CO_2) the United States puts in the atmosphere comes from." They were then asked to rank order (1–4) the relative emissions from four regions (China, the European Union, India, and the United States), followed by the same question about contributions to the concentration of CO_2 in the United States coming from other countries. The section concluded with wording that was identical to the air pollution question: "Imagine that the world's modern factories, transportation and power plants all stopped emitting **carbon dioxide** (CO_2) today. How long would it take for the amount of carbon dioxide (CO_2) in the air to fall back to what it was before those modern factories, transportation and power plants existed?"

Respondents in the mail survey answered questions about causes of climate change, including nuclear power and aerosol spray cans (both of which are *not* significant causes of climate change). These questions read: "Nuclear power is a significant cause of climate change" and "Using aerosol spray cans today is a significant cause of climate change." Respondents answered on a five-point degree of belief scale (T, ~T, ?, ~F, and F).

Respondents in the mail survey answered a series of additional questions about electricity and climate change on five-point degree of agreement or true-false scales. A full copy of the mail survey instrument is available online at http://cedmcenter.org (see footnote 4 in Supporting Information).

2.1.2. Online Survey

Using exactly the same wording, the two questions about the atmospheric lifetime of common air pollution and of carbon dioxide were included in a study conducted using MTurk. Parallel questions for nuclear power and aerosol spray cans were also included in the MTurk survey. The Section 3 reports on the mail survey and the online survey when analyzing these questions (3.1 and 3.2.2). For the remaining analyses, it focuses on the mail survey only unless noted otherwise.

2.2. Respondents

The mail-based study in this article targeted members of the general public in the greater Pittsburgh area. We obtained a list of all addresses by zip code across Allegheny County, PA, and randomly selected 400 households, including two from each zip code. Postcards were mailed to all selected households to notify residents that they had been randomly selected to participate in a survey conducted by Carnegie Mellon University. The aim

was to increase the response rate, which is generally lower for mail-out surveys compared to other recruitment methods.[37] A few days after the postcard was sent, survey packages were mailed. These included a $2 financial incentive for completing the survey and a prepaid, preaddressed envelope to mail back the response. Because responses were returned without identifiers, they were completely anonymous, and we have no information on those who did not respond. One hundred and nineteen responses were received from the mail survey (response rate of 30%). The sample size for the MTurk study was 1,013 responses.

Fifty-five percent of the sample from Allegheny County (AC) are female [AC = 52%; MTurk = 49%; U.S. = 51%]. Ages in the mail sample range from 18 to 93, and the sample mean age (56 ± 17) was statistically higher than Allegheny County's mean age [AC = 41; MTurk = 36.6; U.S. = 36.8]. Mail survey respondents were well educated: 96% had finished high school [U.S. = 88%], 44% had completed college [$U.S._{some}$ = 59%; $U.S._{all}$ = 33%], and 21% had completed graduate training [U.S. = 12%]. Fifty-five percent of the mail survey respondents were Democrats [AC = 60%; MTurk = 46%; U.S. = 47%]; 28% Republicans [AC = 27%; MTurk = 19%; U.S. = 41%]; and 17% independent or other [AC = 13%; MTurk = 35%; U.S. = 12%].

3. RESULTS

3.1. To What Extent Do People Understand the Difference in Atmospheric Residence Times between Common Air Pollution and Carbon Dioxide, as well as the Sources of Each?

Our primary objective was to assess whether people understand the different atmospheric residence times of common air pollution and carbon dioxide. Our analyses suggest that they do not. Fig. 1 provides a histogram of how long respondents believed it would take for common air pollutants to disappear in the atmosphere once all emissions stop, and how long it would take for carbon dioxide to disappear from the atmosphere once all emissions stop. For each time interval, the two dark bars on the left are the results for air pollution, and the two light bars on the right are for carbon dioxide. The solid bars are results from the Allegheny County, PA mail survey; air pollution is the dark solid bar, and carbon dioxide is clear. The pattern and magnitude of average Allegheny County responses showed no statistically

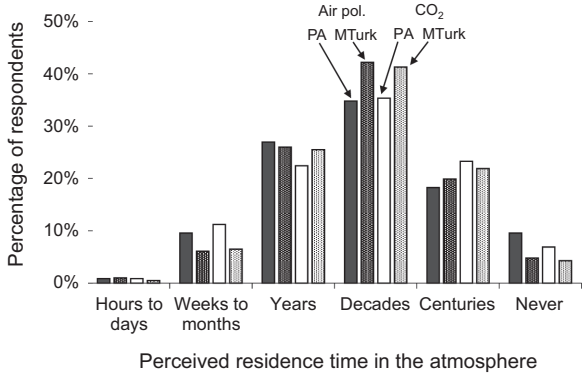

Fig. 1. Histogram of responses to the parallel questions: "Imagine that the world's modern factories, transportation and power plants all stopped emitting [**common air pollution/carbon dioxide**] today. How long would it take for the amount of [**common air pollution/carbon dioxide**] in the air to fall back to what it was before those modern factories, transportation and power plants existed?" For each time interval, the two dark bars on the left are results for air pollution, leftmost from the Allegheny County, PA mail survey ($N = 116$), and the adjacent stippled dark bar is the analogous result for the MTurk study ($N = 1{,}013$). For each time interval, the two lighter bars on the right are results for CO_2, the left from the Allegheny County, PA mail survey, and the adjacent stippled light bar is the analogous result for the MTurk study. The pattern and magnitude of average responses shows no statistically significant difference.

significant difference between common air pollution and carbon dioxide (paired *t*-test, $t = 0.25$, $df = 116$, $p = 0.80$, 95% *CI* [–0.12, 0.15]).[5] The two stippled bars in each time interval are the analogous results for the MTurk study (paired *t*-test, $t = -0.97$, $df = 1{,}012$, $p = 0.34$, 95% *CI* [–0.07, 0.02]).[4]

These results indicate that, on average, our respondents did not differentiate between the atmospheric residence time of common air pollutants—which is typically hours to a few days—and the residence time of carbon dioxide—much of which remains in the atmosphere for centuries. Further, Fig. 2 shows that, in a within-subjects comparison, more than 70% of respondents believed that there was no difference in atmospheric residence time for common air pollution and carbon dioxide. The mean, median, and modal perceived atmospheric residence time for both is in decades.

In the mail survey, we also asked respondents to assess the geographic source of common air pollution and carbon dioxide (i.e., whether the majority

[5] A Wilcoxon signed-ranks test was also conducted and yielded the same result ($Z = -0.22$, $p = 0.83$ for the Allegheny County survey; $Z = 0.97$, $p = 0.33$ for the MTurk survey).

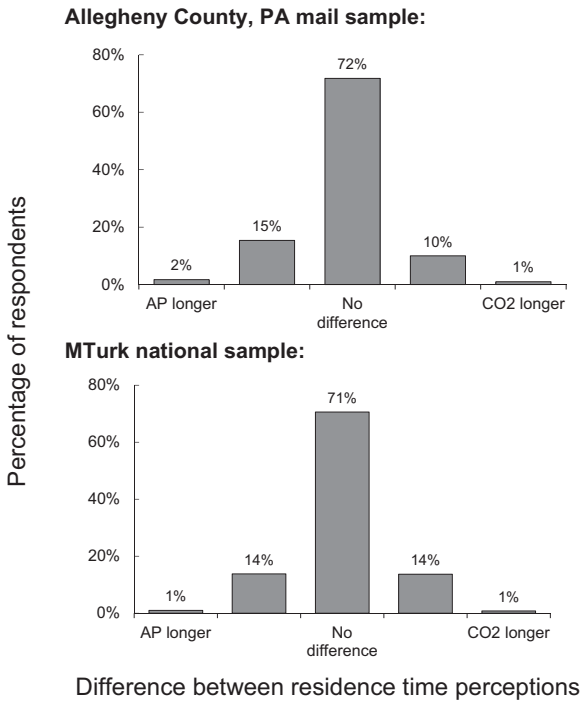

Fig. 2. Respondent-by-respondent distribution of difference in atmospheric residence time between common air pollution and carbon dioxide. Results for the mail survey in Allegheny County, PA are above ($N = 119$) and the national MTurk study are below ($N = 1{,}013$). Total percentage for MTurk is greater than 100% due to rounding. Most respondents in both studies report no significant difference.

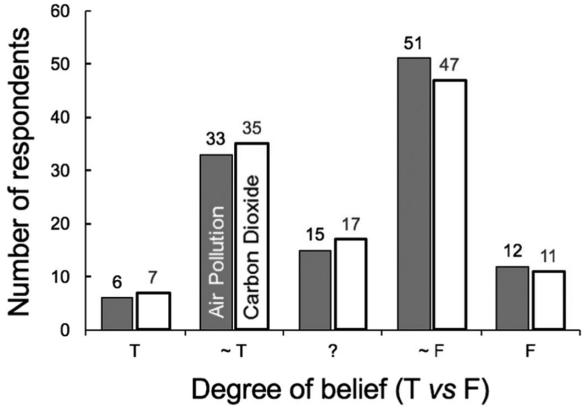

Fig. 3. Distribution of responses in the Allegheny County, PA mail survey to the statement: "Less than a few percent of **the common air pollution/carbon dioxide** that is in the atmosphere here in the United States has come from places that are thousands of miles away." Solid bars on the left are air pollution; open bars on the right are carbon dioxide. The y-axis shows the frequency for each response category. The x-axis represents degree of belief comprising "true," "probably true," "don't know," "probably false," and "false" from left to right (abbreviated T, ~T, ?, ~F, and F).

of **common air pollution/carbon dioxide** here in the United States comes from places that are thousands of miles of away). The results, summarized in Fig. 3, showed no statistically significant difference between responses for common air pollution and carbon dioxide (paired t-test, $t = 0.98$, $df = 117$, $p = 0.33$, 95% CI [–0.10, 0.31]).[6] Our results do not allow us to make statements about what fraction of common air pollution in the United States our respondents believed originates abroad, only that over half believed that fraction to be more than a few percent.

3.2. To What Extent Do People Correctly Identify Causes of Climate Change?

3.2.1. Natural vs Human-Caused Climate Change

A key research question is whether people can identify important causal agents of climate change. Two groups emerged in the survey results: (1) those who believed that climate change is mainly natural (37%), and (2) those who believed that climate change is mainly caused by human activity (63%). More than one-third of respondents incorrectly cited natural causes as primary drivers of recent changes in the climate.

3.2.2. Nuclear Power and Aerosol Spray Cans

Beliefs that nuclear power and beliefs that aerosol spray cans are significant causes of climate change were positively correlated (Spearman's $\rho = 0.41$; $p < 0.01$). Fifty-six percent of respondents either did not know or incorrectly believed that nuclear power is a significant cause of climate change; 60% did not know or incorrectly believed that aerosol spray cans are a significant cause of climate change.

The distributions of responses for nuclear power are more similar across natural versus human-causation beliefs than the distributions of responses for aerosol spray cans (Table I). Of the 41 respondents who believed that climate change is mainly natural, 27% correctly judged as false the statement that nuclear power is a significant cause of climate change. Fifty-six percent did not know or incorrectly believed that nuclear power is a significant cause of climate change.

[6] A Wilcoxon signed-ranks test was also conducted and yielded the same result ($Z = –0.96$, $p = 0.34$).

Table I. Distributions of Responses According to (1) People's Degree of Belief in Nuclear Power and Aerosol Spray Cans as Causes of Climate Change (Both of Which Are Not Significant Causes) and (2) Natural versus Human-Caused Climate Change Beliefs

		Climate change is mainly caused by?	
(1)	(2)	Natural causes ($n = 41$)	Human causes ($n = 69$)
Nuclear power is a significant cause of climate change. ($n = 110$)	True, Probably True	29%	32%
	Don't know	27%	25%
	False, Probably False	44%	43%
Using aerosol spray cans today is a significant cause of climate change. ($n = 110$)	True, Probably True	22%	54%
	Don't know	22%	16%
	False, Probably False	56%	30%

A smaller proportion—44%—did not know or incorrectly believed that aerosol spray cans are a significant cause of climate change, χ^2 (1, n = 41) = 1.67, p = 0.20. A statistically significant Spearman rank correlation was found between natural climate change beliefs and belief that aerosol spray cans are a significant cause of climate change (ρ = –0.22; p = 0.02). Only 8 of the 41 (20%) were confident that aerosol spray cans are not a significant cause of climate change (i.e., judged this statement false).

Of the 69 respondents who believed that climate change is mainly caused by human activity, 20% correctly indicated that nuclear power is not a significant cause of climate change. Fifty-seven percent either did not know or falsely believed that nuclear power is a significant cause of climate change. This result suggests that no matter whether people think that climate change is natural or human induced, they are equally likely to hold the incorrect belief that nuclear power is a significant cause of climate change (56% and 57%, respectively). This trend does not hold for aerosol spray cans. Seventy percent of those who recognized that humans have caused climate change either did not know or incorrectly believed that aerosol spray cans are a significant cause of climate change. Only 2 of the 69 (3%) were confident that aerosol spray cans are not a significant cause of climate change. This is proportionally lower than the 20% of natural climate change believers who were confident that aerosol spray cans are not a significant cause of climate change, χ^2 (1, $n = 115$) = 42.2, $p < 0.01$.

The parallel questions for nuclear power and aerosol spray cans in the MTurk survey revealed similar results; a majority of those in the national sample who were randomly assigned to receiving the question thought that these were significant contributors to global warming or reported that they did not know (61% for nuclear power and 71% for aerosol spray cans, $N = 524$). However, for the small subset of these MTurk respondents who thought that human activities have not contributed to global climate change ($n = 33$), a majority answered correctly that nuclear power (79%) and aerosol spray cans (69%) are not major causes of global warming.

3.2.3. What Can and Should Be Done about Climate Change?

Sixty percent of Allegheny County respondents disagreed that we will be able to stop future changes in the climate, if they are occurring and ever get serious. Of these, nearly all (91%) believed that the only way to avoid possible future serious changes in the climate is to take action to stop them now. Eighty-one percent of Allegheny County respondents agreed that the only way to avoid possible future serious changes in the climate is to take action to stop them now.

Allegheny County respondents who thought that climate change is primarily caused by natural causes tended to disagree that "[i]f the climate is changing, there is not much people *can* do about it" (66% responded disagree/strongly disagree), but were less likely to do so than those who thought that climate change is primarily caused by human activities (66% vs 94%), χ^2 (1, $n = 115$) = 7.26, $p < 0.01$. Further, of those who thought that climate change is primarily caused by natural processes, 41% responded disagree/strongly disagree that if changes in the climate are occurring, and these changes ever get serious, we will be able to stop them in the future, as compared to 71% for those who think climate change is primarily caused by human activities, χ^2 (1, $n = 121$) = 22.0, $p < 0.01$.

Despite this, only 7% (3 of 41) of those who viewed climate change as primarily caused by natural

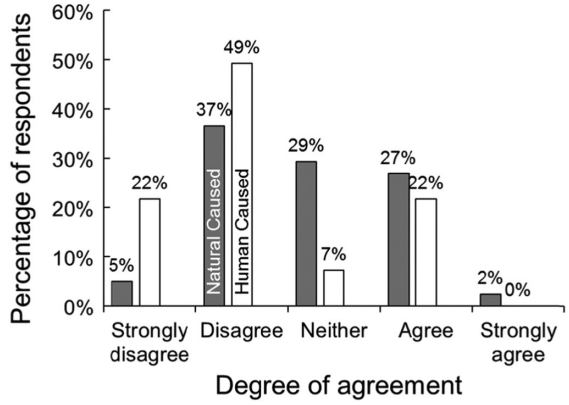

Fig. 4. Distribution of responses in the Allegheny County, PA mail survey to the statement: "If the climate is changing, and those changes ever get serious, we'll be able to stop them in the future when they happen." Responses are separated by natural-caused (solid bars on the left) and human-caused (open bars on the right) climate change beliefs. The y-axis shows the frequency for each response category. The x-axis represents degree of agreement comprising "strongly disagree," "disagree," "neither disagree nor agree," "agree," and "strongly agree" from left to right.

processes thought that we should not do anything about it, similar to the less than half a percent (3 of 69) of those who saw climate change as primarily caused by humans. Sixty-three percent of natural climate change believers indicated that they agree or strongly agree that the only way to avoid possible future serious changes in the climate is to take action to stop them now (as compared to 91% of those who believed that climate change is primarily caused by human activities), χ^2 (1, $n = 115$) = 16.0, $p < 0.01$. The distribution of responses for the statement, "If the climate is changing, and those changes ever get serious, we'll be able to stop them in the future when they happen," is provided in Fig. 4 for all respondents.

3.3. To What Extent Do These Beliefs Affect People's Support to Take Action Now against Future Serious Changes in the Climate?

To address the third research question, we conducted a logistic regression in which the binary dependent variable reflected responses to: "The only way to stop future serious changes in the climate is to take action to stop them now." Those who agreed or strongly agreed with this statement were coded as "1," and those who disagreed or strongly disagreed with this statement were coded as "0." We estimated support for this statement as a function of beliefs about climate change, while controlling for political party (Table II).

Next, we conducted a factor analysis to reduce the number of intercorrelated independent variables and to alleviate associated concerns about multicollinearity.[7] A total of five reliable factors were found: (1) Democrat; (2) Indiscriminate Green Beliefs (3 items; Cronbach's $\alpha = 0.59$); (3) Residence Time (2 items; Cronbach's $\alpha = 0.88$); (4) Distant Source (2 items; Cronbach's $\alpha = 0.69$); and (5) Electricity Source (2 items; Cronbach's $\alpha = 0.78$). For each multi-item factor, we therefore created a new variable (see Supporting Information for detailed description of computation).

Model 1 includes two factors: Democrat and Residence Time (i.e., the misunderstanding of atmospheric residence time of common air pollution and carbon dioxide (Table II)). Pseudo R^2 for model 1 approximates 0.17 (Nagelkerke). Only Democrat is statistically significant ($p = 0.01$). Model 2 includes all five independent variables. Pseudo R^2 for model 2 approximates 0.66 (Nagelkerke). In model 2, Democrat and Indiscriminate Green Beliefs are statistically significant ($p = 0.01$ and $p < 0.01$, respectively). Of note is that the Residence Time factor was not significant in either model (Table II). In other words, atmospheric residence time beliefs were not related to support to take action, as part of the logistic regression.

The Indiscriminate Green Beliefs factor combined responses to three related survey questions. If people held "Indiscriminate Green Beliefs," they met at least one of the following requirements: (1) answered true or probably true that nuclear power is a significant cause of climate change; (2) answered true or probably true that aerosol spray cans are a significant cause of climate change; or (3) answered true or probably true that renewable forms of energy (like solar and wind) could reliably supply U.S. electricity demands. If any of these requirements were met, the respondent received a coding of "1," signifying that he or she had Indiscriminate Green Beliefs. All other respondents were coded as "0."

Of respondents who self-identified as Democrats, 48 had Indiscriminate Green Beliefs.[8] For those

[7] When all items were included as individual predictors in the regression, we found some indication of multicollinearity (variance inflation factors ranged from 1.27 to 2.71), and none of the individual parameter estimates were significant ($p > 0.99$ for all).

[8] $N = 101$ for the Indiscriminate Green Beliefs analyses, as sample size varied slightly due to item nonresponse.

Table II. Summary of Variable Parameters and Significance Levels for Logistic Models

	Model 1 ($n = 103$)		Model 2 ($n = 91$)	
Variables	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Democrat	7.71 (1.55, 38.36)	0.01	104.53 (2.94, 3,715.28)	0.01
Residence Time	1.20 (0.44, 3.27)	0.72	0.37 (0.09, 1.60)	0.20
Indiscriminate Green Beliefs	–	–	212.23 (7.12, 6,330.36)	<0.01
Distant Source	–	–	0.28 (0.04, 2.20)	0.23
Electricity Source	–	–	4.31 (0.61, 30.35)	0.14
Constant	3.79	<0.01	0.21	0.45
Nagelkerke R^2	0.17		0.66	
Wald Model Evaluation	$\chi^2(2) = 8.87, p = 0.01$		$\chi^2(5) = 31.97, p<0.01$	
Hosmer–Lemeshow Goodness of Fit	$\chi^2(3) = 2.56, p = 0.47$		$\chi^2(8) = 4.72, p = 0.79$	

who held Indiscriminate Green Beliefs and were Democrats, the probability of believing we should act now to combat climate change was virtually 100%. For the 13 Democrats who did not have Indiscriminate Green Beliefs, the probability of believing that we should act now to combat climate change was 95%. Of those respondents who self-identified as Republicans, 29 had Indiscriminate Green Beliefs. For those who held Indiscriminate Green Beliefs and were Republicans, the probability of believing we should act now to combat climate change was 98%. For the 11 Republicans who did not have Indiscriminate Green Beliefs, the probability of believing we should act now to combat climate change was 17%.

4. CONCLUSION

Previous studies of educated laypeople revealed a variety of public misunderstandings about the causes of climate change[7–9] but did not systematically explore whether people understand the very long (>100 years) residence time of carbon dioxide once it enters the atmosphere. This article found that people did not differentiate between the residence time of common air pollution (which they dramatically overestimated) and carbon dioxide (which they dramatically underestimated). Such a belief in a short residence time could lead people to the false conclusion that if and when the effects of climate change ever get serious, those effects could be reversed in just a few decades or less by reducing emissions of CO_2. However, that is not the case: once CO_2 enters the atmosphere, much of it remains there and contributes to warming for many centuries. A communication strategy that continues to link CO_2 with air pollution may be unwise if it perpetuates this misunderstanding.

While many people accept that changes in the climate are occurring, misconceptions persist about the cause of those changes. Results obtained in our Pennsylvania sample suggest that despite efforts to correct a variety of misunderstandings over the last decade, gaps still exist.

Knowledge deficits are rarely the primary drivers of policy support.[38] Hence, it is unlikely that support for climate abatement is determined by personal views about atmospheric residence time. However, specific knowledge sometimes does explain meaningful differences in policy support.[39] Further, it is arguable that voters and policymakers will be able to make more informed decisions about which policies to support if they understand that successful climate policy will require consistent attention to reducing CO_2 emissions over the course of many decades, due to the long-lived nature of CO_2 and its persistent impact on climate.

While in some respects discouraging, our results do offer two signs of hope. The first is that, compared to an earlier survey,[9] a considerably higher proportion of survey respondents now understand that burning fossil fuels releases carbon dioxide and that changes the climate. Perhaps that means that with well-designed, tested analogies—such as filling bath tubs that have large faucets and very small drains[40,41]—wider understanding of the long atmospheric residence time of carbon dioxide and its fundamental policy implication can be achieved both in the general public and among members of the media, opinion leaders, and decisionmakers. The second is the strong support for action *now*, although this appears to result primarily from indiscriminate green beliefs rather than an understanding of the long-lived problem that continued emissions creates.

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