Climate change and the shadow of the future

Sofia Berrospi[1‡]
Guilherme Fasolin[1]
James Bisbee[1]

[1]Department of Political Science, Vanderbilt University

[‡]To whom correspondence should be addressed: sofia.berrospi@vanderbilt.edu

August 25, 2024

Abstract

The consequences of climate change are becoming more tangible and severe over time. Young people are the ones closer to experiencing these imminent consequences. Despite this, age has been overlooked as a significant explanatory variable in the literature on climate change opinions. This article seeks to fill this gap. We synthesize different studies across psychology, social sciences, and biology to generate three versions of a standard rational actor model of a future-discounting agent whose shadow of the future is endogenous to their age. We then evaluate our expectations using data from the Climate Change in the American Mind survey spanning from 2008 to 2022, encompassing responses from over 30,000 participants. Our descriptive results mainly suggest a negative relationship between age and concern, but we also find evidence of a curvilinear relationship. We disentangle age and cohort effects and find no significant cohort effects. In addition, we provide evidence regarding risk perceptions and the role of the information environment. Older participants exhibit heightened concern for the harm climate change may cause them personally compared to the harm it may have on the United States, developing nations, or future generations. They also anticipate climate-related harm to manifest sooner than younger participants. Finally, we find that younger individuals are not inherently more informed about climate change and that self-reported media exposure increases with age. While merely descriptive, our findings suggest scholars of climate change and policy-makers should consider age as an important variable in explaining climate change public opinion.

Keywords: Climate change, generational politics

Introduction

Climate change is a political issue whose worst costs are yet to be realized. While temperature records are set annually, and draughts and extreme weather worsens across the world, climate scientists continue to predict that the most painful consequences of global warming will not begin to manifest until 2050. That year, once so remote sounding, grows decreasingly abstract as younger generations become politically aware.

The dynamic quality of climate change is one of the main explanations for why humanity has failed to prevent it, despite a wealth of knowledge about how we could and why we should. Trade-offs between benefits now, costs "kicked down the road" is an almost axiomatic demonstration of time inconsistent preferences, in which previous generations' desires for consumption will be paid for with future generations' hardship. And for much of the brief history of climate change as a politically salient issue, the future costs were abstract enough to reduce our understanding of its politics to this tidy model.

But as our species continues to march down this road, the once-abstract future costs are becoming increasingly concrete. And in particular, the costs are becoming increasingly concrete for younger generations. Years like 2050 and 2100 are now seemingly just around the corner, raising the question of whether these younger generations are more aware of, concerned about, and activated by climate change.

Despite the straightforward intuition of why we might expect this to be the case, the extant political science literature has spent relatively little attention to the relationship between age and attitudes on climate change. Most studies often include age as a control variable in models of climate beliefs, yet without thoroughly theorizing its conceptual relevance [Van der Linden, 2017]. Perhaps this inattention is the result of more powerful predictors in the form of partisanship [Hornsey et al., 2016, Egan and Mullin, 2017], or perhaps it is due to the sense that the familiar model of time inconsistent preferences has historically been

enough to fully explain the politics of climate change policy. However, as we demonstrate in this paper, age is a persistent and powerful predictor of climate change attitudes, although in ways that require a more nuanced understanding than a standard model involving the shadow of the future. As we show, the most intuitive theories about rational self-interest do not satisfyingly explain the patterns that we find linking age and concern, with the relationship between age and concern exhibiting a curvilinear pattern, suggesting that it is the youngest and the oldest who are more concerned.

Our paper makes two contributions to the research on attitudes about the environment in the United States. First, we bring age back into the conversation as an important predictor whose influence will theoretically increase over the next several decades. Previous research has largely treated age as a nuisance or control variable, and those surveys in which this is not the case find mixed results. Second, we draw on a diverse theoretical literature to provide several explanations for why we might expect to see a curvilinear relationship between age and concern. While the current manuscript is unable to convincingly adjudicate between all of these explanations, relying – as it does – on observational survey data, we are able to rule out some and leave the remainder to future research.

1 Existing Research

Our focus bridges several topics and disciplines, including the topics of age, public opinion, and the environment; as well as the disciplines of political science, sociology, and psychology. Across these disparate bodies of work, there is a growing consensus that – at least in the United States – politics is most prognostic of attitudes on the environment [Egan and Mullin, 2017, Druckman and McGrath, 2019, Egan and Mullin, 2024]. The predictive power of partisanship and ideology dominates all empirical patterns on attitudes ranging from knowledge of the issue [Malka et al., 2009], belief that it is real [Hornsey et al., 2016], concern about

its impacts [Wood and Vedlitz, 2007], and support for specific policies [Hart and Nisbet, 2012, McCright et al., 2014]. Moreover, the predictive power of politics is a relatively recent phenomenon, and one which mirrors issue evolution on other increasingly polarized topics [Egan and Mullin, 2017]. It wasn't until the mid-1990s that public disagreement over climate change began to sort itself by political party, and the trend has continued thereafter.

While not nearly as powerful as partisanship, there are several other predictors of attitudes on the environment that persist. At the individual-level, gender and risk perception have proven to be durable but second-order predictors, with women expressing more concern than men, as do more risk-averse respondents writ large [Blocker and Eckberg, 1997, Bush and Clayton, 2023]. At the contextual-level, a flurry of work has linked attitudes about the environment to local phenomena including weather, temperature, and pollution [Egan and Mullin, 2012, Hazlett and Mildenberger, 2020, Marlon et al., 2021].

Our predictor of interest – age – has also occasionally cropped up in existing work, although has rarely been the measure of substantive interest. Furthermore, even when not included solely as a control variable, the association between age and attitudes has been inconsistent across the existing literature [Wood and Vedlitz, 2007, Beiser-McGrath and Huber, 2018, Franzen and Vogl, 2013]. While some studies have concluded that older Americans are less concerned about climate change, the conclusion is not robust. Perhaps most related to our contribution is a recent working paper by Alexander F. Gazmararian who finds that the experience of being a (new) parent increases support for addressing climate change, a pattern he attributes to changing time horizons.[1]

We contribute to this literature by arguing that age is becoming a robust predictor of climate attitudes, and is doing so in a way that is not simply a reflection of shifting partisanship or ideology across an individual's lifetime. We flesh out the theoretical intuition

[1] https://alexgaz.scholar.princeton.edu/sites/g/files/toruqf4651/files/documents/Future.pdf

in more detail in the subsequent section, but pause here to acknowledge some competing explanations for why age might matter to understanding attitudes on the environment. First, it may be that age is correlated with other factors that influence climate attitudes, such as partisanship and news consumption. For example, it is a well-documented pattern that Americans become more conservative as they grow older. Alternatively or additionally, news consumption patterns can also shift with age. These two explanation underscore the importance of elite cues from politicians and the media in shaping attitudes, and point out that patterns we attribute to age might instead be attributable to the information environments Americans of different ages find themselves in.

Second, while it may be true that age has an independent association with attitudes on the environment, this might not reflect the rational self-interest explanation we suggest. Instead, age might influence risk preferences, as individuals grow more or less risk averse as they age. Existing research has argued that younger individuals are more risk averse than middle aged people because they are less knowledgeable about the world, while the elderly are also more risk averse due to their greater vulnerability to physical harms. Such an explanation would predict a U-shaped relationship between age and concern about climate change.

Finally, there are alternative explanations that emphasize sociotropic considerations, in which older individuals care more about future generations, especially those that are still only children today. Evidence is found in the education policy literature, which rejects the expectation of "gray peril" in which aging populations underfund schools due to not directly benefiting from them [Berkman and Plutzer, 2004]. To the contrary, the evidence suggests that older Americans support school spending when they are not new arrivals to the district, a phenomenon the authors refer to as "loyalty", or an emotional bond between older residents and their community's institutions. A similar logic undergirds Gazmararian's working paper which finds that new parents are 4.3 percentage points more likely to support combat-

ing climate change than otherwise similar individuals without children (https://alexgaz.scholar.princeton.edu/sites/g/files/toruqf4651/files/documents/Future.pdf).

2 Theoretical Intuition

The discussion above suggests two alternative theoretical frameworks: a strictly rational self-interest model versus a bounded-rationality model. The former encodes the logic of expected costs and benefits, but can be modified to accommodate other-regarding preferences such as those suggested by the educational literature on intergenerational "loyalty". The latter starts from the assumption that individuals don't have the time or energy to exert on learning about climate change, and instead update their beliefs based on elite or media cues. We sketch the logic of each in the following two sections.

2.1 Rational Self-Interest

We start our description of the rational self-interest framework with a straightforward utility function with discounting.

$$u(\mathbf{x}) = \sum_{t}^{T} \delta^{t-1} u(x_t) \tag{1}$$

where x_t is pollution (or some other climate-related cost) and $u(x_t)$ captures the disutility associated with consuming this cost. The discount factor δ is between zero and one, reflecting the assumption that individuals are more sensitive to more temporally proximate costs. For a given δ, it is straightforward to see that the disutility is increasing in T, or the total number of periods into the future we aggregate. For two individuals i and j, we can treat all elements of the above function as constant with the exception of T. $T_i < T_j$ is equivalent to saying that the number of periods over which we aggregate for i is less than that for j or, substantively, that i's remaining years are less than j. Thus the simple discounting model

generates the prediction that i will experience less disutility from climate change than j solely as a function of their life expectancy, as long as $\delta > 0$.

This straightforward intuition can be complicated in three ways, even reversing the empirical expectation that younger individuals should rationally be more concerned about climate change than other individuals. First, the endogeneity of one's discount factor to their age (denoted with δ_i) is a well-studied question in psychology and behavioral economics (see Trostel and Taylor [2001], Carstensen [2006], Sozou and Seymour [2003], Block et al. [1998], Verhaeghen and Cerella [2002], and Seaman et al. [2022] for a meta analysis). On the one hand, there are the familiar stereotypes of younger people behaving more recklessly, as expressed in crime rates, certain types of mortality data, and any child's impatient frustration. Theoretically, there are a few justifications for why younger people might discount more heavily (i.e., have lower values of δ). For example, less experience means that the world has greater uncertainty and risk, and that therefore younger people will discount more simply because they are less certain if they will be able to obtain the benefits of investment [Read and Read, 2004].

Second, if we also endogenize the utility function itself to age – i.e., to capture the notion that our ability to enjoy things declines as we age, due to waning physical ability, denoted with $u_i(\cdot)$ – then the discount factor should also be greater for younger than for older people [Trostel and Taylor, 2001]. Alternatively, one might imagine that the cost x is higher for older people, meaning that the costs of climate change carry greater disutility. Although these adjustments work in opposite directions at the level of the utility function, they both generate the same prediction that older individuals should be more concerned about climate change than younger.

Third, there is the popular observation that our perception of time's passage changes as we age, with older people expressing the sensation that "time flies". A number of explanations for this phenomenon are found across disparate bodies of research [Block et al., 1998]. On

the one hand there is the simple math of fractions: a year to a 60 year old is half as large as a year to a 30 year old, when conceptualized as the proportion of their existence [Löckenhoff, 2011]. A related but distinct explanation is found in biology where the growing complexity of the human brain – literally the number of neurons and linking synapses – reduces the number of images a human can experience for the same nominal unit of time [Bejan, 2019]. In brief, older brains are characterized by both a greater distance that signals must travel as well as less efficient neural pathways, which combine to reduce the number of images that reach the cortex in a given span of nominal time. Crucially, our perception of time is defined by the changes in images that reach the cortex. As the rate of these images slows with age, we perceive time to be moving faster. This observation is translated into our model with T_i, capturing the combined intuition of the number of remaining years being both nominally different, as well as subjectively different.

Each of the preceding extensions contradict the rational self-interest expectation that younger people have more to lose from climate change, and therefore should care more about it. Existing empirical studies of how age influences our expectation of future costs and benefits have returned mixed evidence in tightly controlled laboratory settings. In some cases, the association is declining monotonically with age, consistent with the standard rational self-interest story. In others, there is evidence of an U-shaped pattern, with early to middle-aged adults caring least, while the youngest and oldest groups are more concerned about future payoffs [Read and Read, 2004].

2.2 Information Environments and Learning

The preceding framework assumes that x is commonly known, even if some modifications allow it to vary by age. But a separate family of theories allow for the cost itself to be only noisily ascertained, reflecting the uncertainty around the true costs of climate change [Zechman, 1979, Achen, 1992, Bartels, 1993, Druckman and McGrath, 2019]. The costs are

thus not a single value x, but rather are represented by a (typically) normal distribution with a standard deviation: $x \sim \mathcal{N}(\mu, \sigma)$, where μ is the true but unknown cost, σ is the "credibility" attached to the signal, and x is a draw from this distribution.

In this setting, individuals are (boundedly) rational Bayesians. They observe signals x that contains information about the costs of climate change, and update their beliefs in which their posterior belief is a weighted combination of their prior belief and the signal. This posterior might still then be processed via the utility function logic described above, or it might instead simply become their new attitude. The difference between this framework and the preceding is that these signals can come from a variety of sources, including political elites and the media. Crucially, these sources and the credibility attached to them can vary by the individual, with the standard assumption being that both the signals x and the credibility σ are specific to an individual.

A familiar example to scholars of contemporary American public opinion would be a report issued by climate scientists that is covered by the media. Conservatives are likely to be exposed to this report from coverage by conservative media, which might both downplay the seriousness of the findings, and cast doubt on their credibility. Liberals, on the other hand, are likely to learn of this report via ideologically congruent media which emphasize both the seriousness of the findings and the credibility of the research. In the notation of the Bayesian framework, the conservative signal x_c is less than the true state of the world μ, while the liberal signal x_l is greater than it, and the credibility attached by conservatives to the report is lower than that attached by liberals ($\sigma_c > \sigma_l$, where larger values of σ reflect lower credibility). Thus, the same scientific report will produce offsetting reactions among ideologically diverse individuals. We provide a visualization of this intuition in Figure 1.

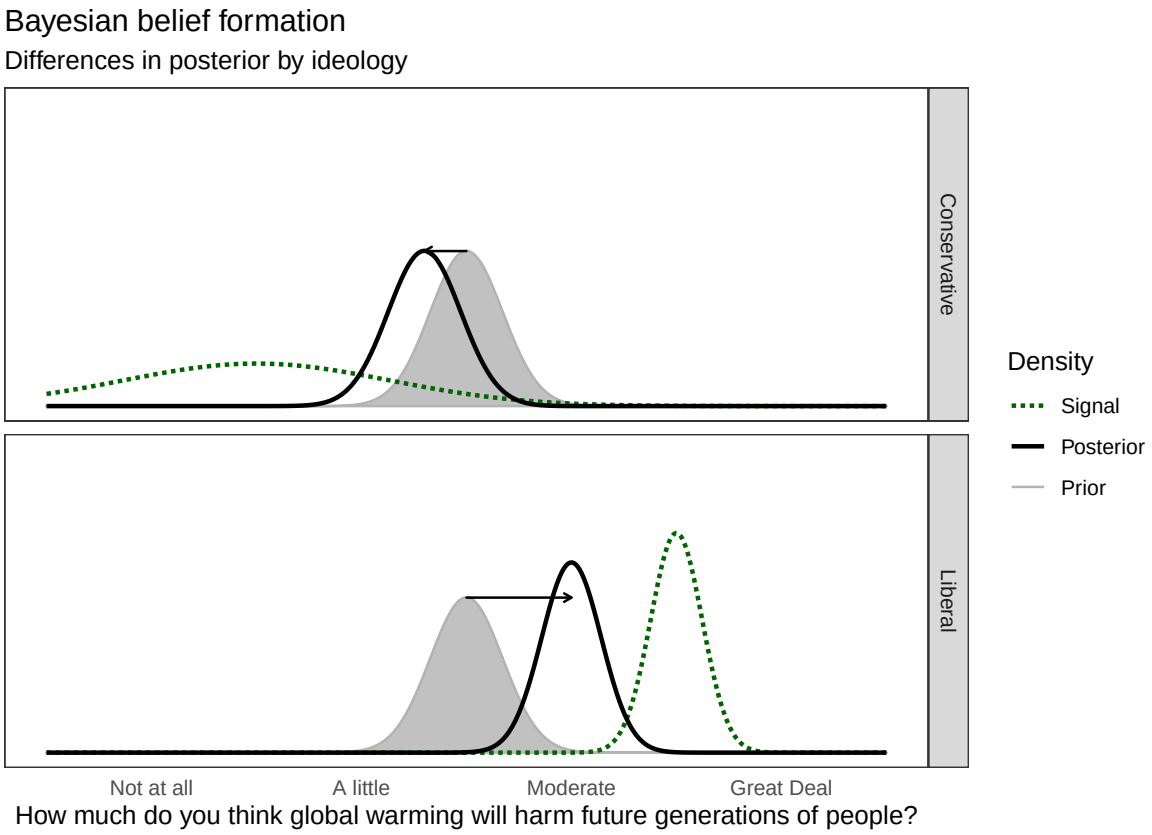

Figure 1: Bayesian updating example. Conservatives learn about a scientific report on climate change from conservative outlets, whose signal x_c is less than the true state of the world μ and who assign very little credibility to the report. Liberals learn of the same report from liberal outlets, whose signal x_l is greater than μ and who assign much higher credibility, meaning $\sigma_l < \sigma_c$. As a result, conservatives move in a less concerned direction while liberals move in a more concerned direction.

2.3 Hypotheses

The preceding theories generate the following hypotheses which we test in the observational data. Starting with the simplest model of rational self-interest with common parameters x, $u(\cdot)$ and δ, the simple logic of life expectancy generates the hypothesis that younger individuals should be more concerned about climate change since they will bear the brunt of the costs.

H1: Concern about climate change is declining in age.

Relaxing these strict assumptions and endogenizing costs, discount factors, and utility functions produces more complicated expectations. In line with the existing research, we might expect to see a U-shaped association, in which the most concerned individuals are the youngest and the oldest, while the middle aged are least concerned. Alternatively, depending on how the subjective perception of time varies with age, we might even expect that the pattern should be reversed, with the oldest being most concerned with climate change which appears to them to be right around the corner.

H2: Concern about climate change is either **(H2.a)** increasing in age or **(H2.b)** decreasing and then increasing in age.

To test the sociotropism expectation, we examine whether there is variation among older individuals as a function of their ties to future generations through children and grandchildren. Here we expect that individuals with children would have more concern about climate change than those without.

H3: Concern about the harms caused by global warming to future generations is higher among younger and older respondents.

Turning to the Bayesian models, we require additional predictors to test these expectations. Specifically, we require measures of media coverage of climate change that our subjects are exposed to, and test whether these cues dominate the variation in concern. In our observational setting, a causal interpretation of these patterns is impossible, given concerns about reverse causality. Nevertheless, our analysis can rule out this explanation if no evidence manifests or, alternatively, not rule out the age framework if it persists despite including media coverage as a control.

H4: Concern about climate change should be greater among those whose information environments contain more signals about climate change.

3 Data and Methods

3.1 Data

Our individual-level dataset ($N = 30136$) comes from the Climate Change in the American Mind survey (CCAM), a nationally representative survey of American adults conducted twice a year by the Yale Program on Climate Change Communication and the Center for Climate Change Communication at George Mason University. Samples were collected from the online Ipsos KnowledgePanel, which uses a probability proportional to size sampling method. Respondents completed the questionnaires using a web-based platform.

Spanning 26 waves from 2008 and 2022, the survey is appropriate to test our hypotheses given it asks a rich battery of questions to examine public opinion on climate change.[2] In particular, we use the question *"How worried are you about global warming?*, measured in a 4-point scale, to assess climate change concern. We dichotomized this variable, so our concern outcome variable is 1 for options 4 ("Very worried") and 3 ("Somewhat worried"), and 0 otherwise ("Not at all worried" and "Not very worried"). We also use the following risk perception questions as dependent variables: *"How much do you think global warming will harm: you personally/people in the US/people in developing countries/plant and animal species/future generations?"*, measured in 4-point scale, and *"When do you think global warming will start to harm people in the United States?"*, measured in a 6-point scale. We visualize overtime changes in the sample averages of these outcomes in Figure 2, highlighting the systematic increase in relevant attitudes about global warming over time.

Our main explanatory variable is age, treated as a continuous variable. We supplement the analysis using a categorical variable of generations (or birth cohorts), which includes the Silent Generation (born before 1946), Boomers (1946-1964), Gen Xs (1965-1980), Millennials

[2]We aggregate these waves to the year for expositional simplicity.

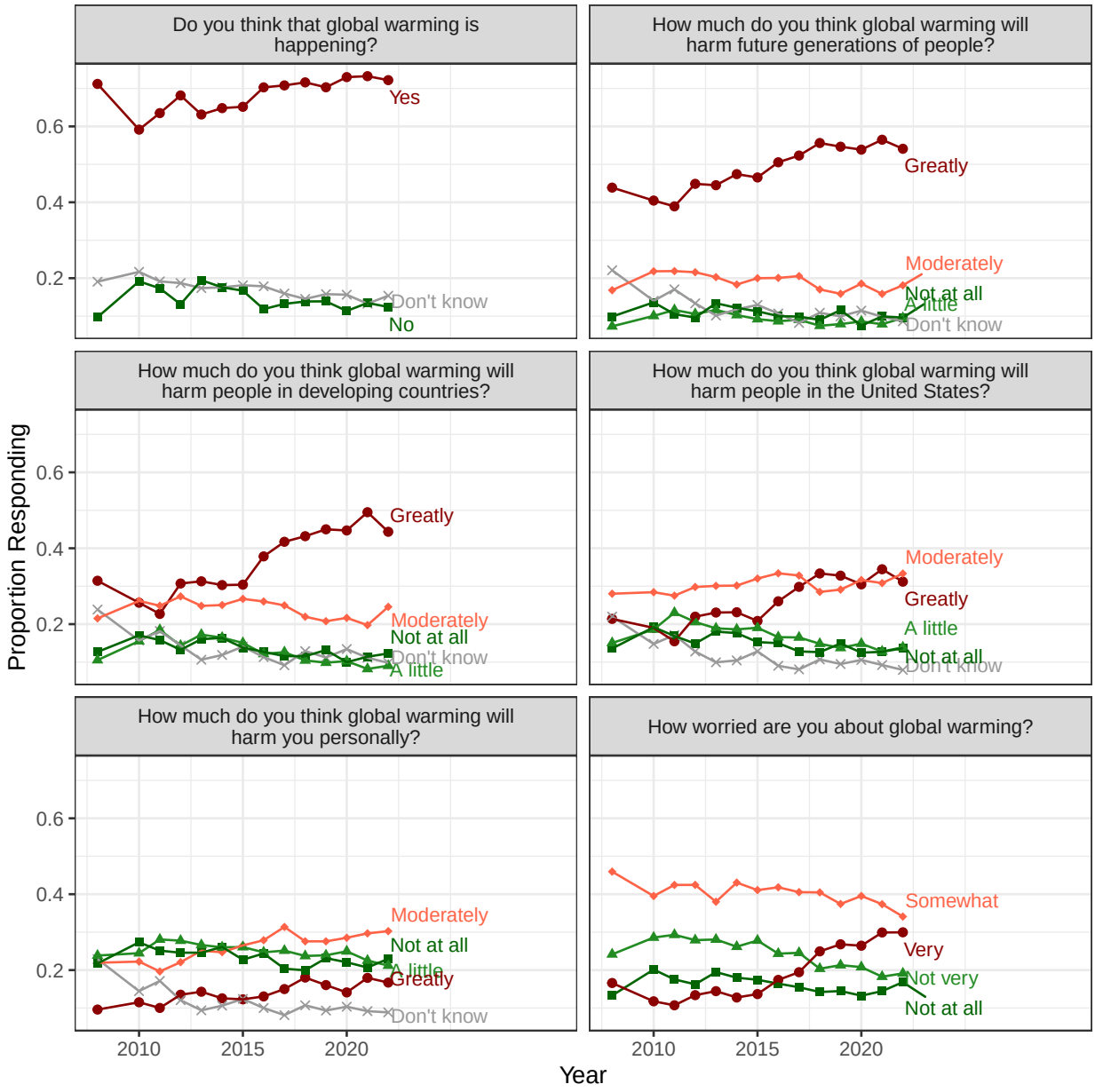

Figure 2: Proportion answering to each question (panels) over time (x-axes).

(1981-1996) and Gen Zs (born after 1996). We visualize the distribution of generation survey wave in Figure 3, highlighting the prevalence of Boomers in our data. This prevalence is further reinforced in Figure 4 which plots the distribution of age by generation. While we have reasonable overlap across adjacent generations, allowing us to estimate the attitudes of a 30 year old Millennial versus a 30 year old Gen X member, we lack the longer panel that would facilitate a more rigorous adjudication between age and cohort effects on attitudes.

We return to this empirical challenge below.

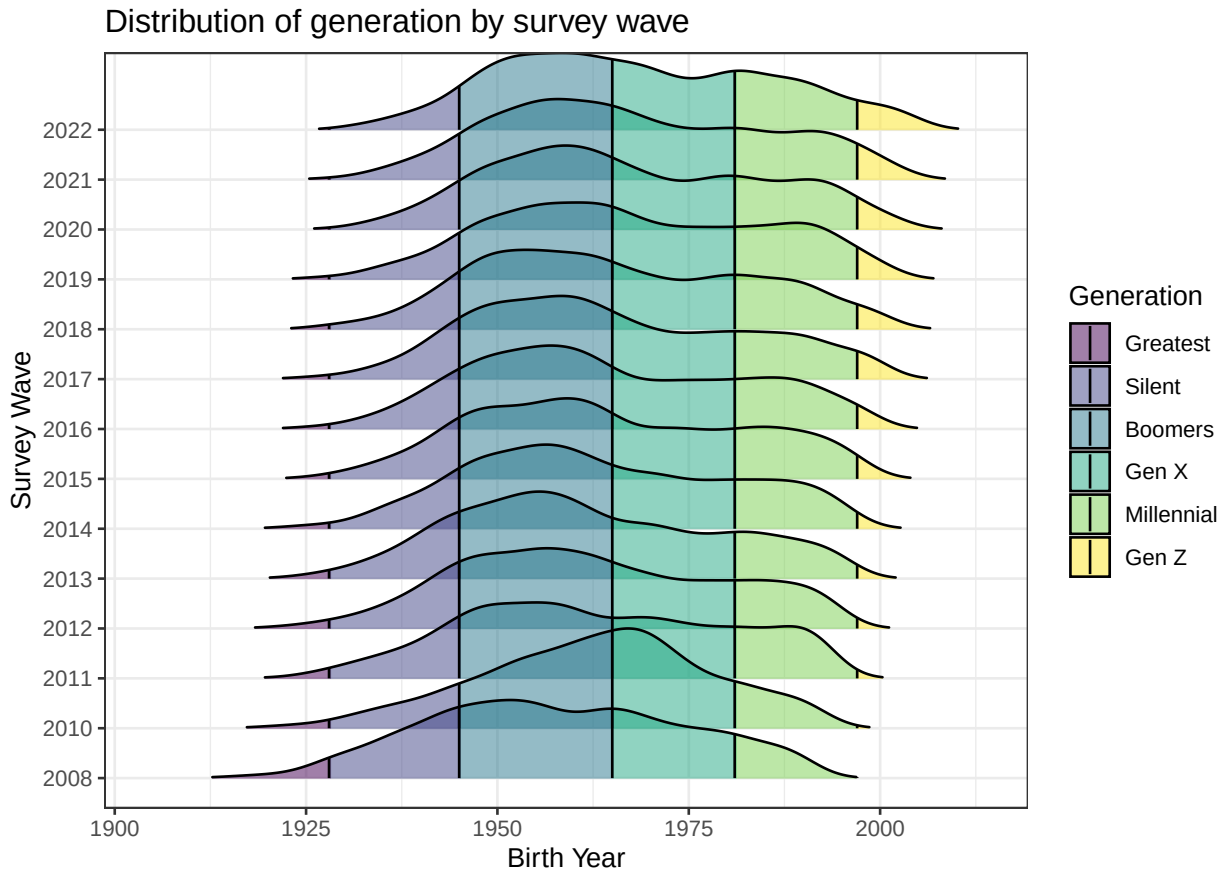

Figure 3: Distribution of respondents by birth year (x-axis), generation (color) and survey wave (y-axis).

As for other explanatory variables, we control for several demographic and economic variables, namely gender, race, education, income, marital status, and employment status. Furthermore, we include party, which is the most powerful predictor according to the literature, and a variable with categories based on party and ideology (e.g. "Liberal Democrat").

3.2 Methods

While the main focus of our analyses of these data is descriptive, we use our time series-cross sectional data to run descriptive regressions and incorporate both year and region fixed

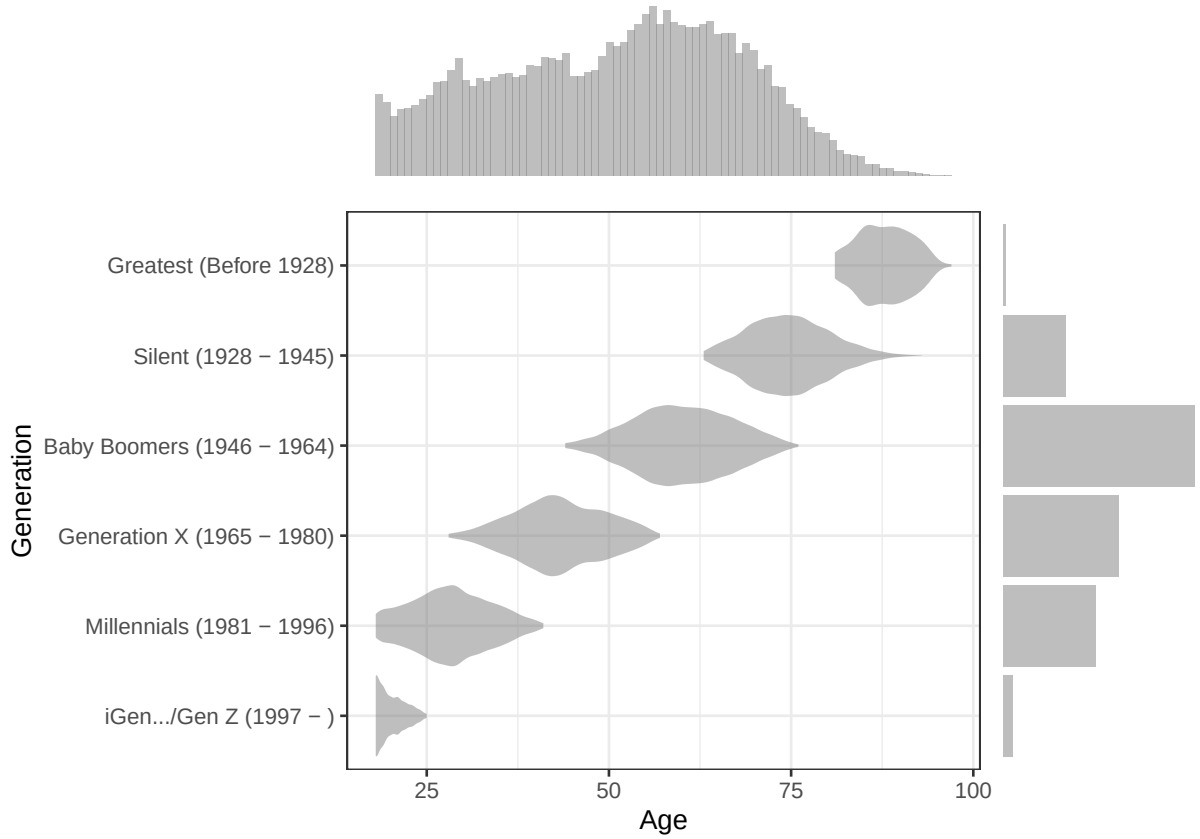

Figure 4: Distribution of respondents by age (x-axis) and generation (y-axis). Marginal distributions presented at top and right of the main panel.

effects. In addition, while our data relies on United States samples only, there's evidence that demographic factors such as gender, influence climate change attitudes worldwide [Bush and Clayton, 2023].

Our identification strategy relies on the conditional independence assumption and thus, we argue that the potential outcomes and treatment are independent conditional on our selection of covariates. As we progressively incorporate additional covariates, we conduct several specifications using both age and generation as our main independent variables. The most rigorous specification is the following:

$$
\begin{aligned}
Concern_{it} = \alpha + \beta_1 Age_{it} + \beta_2 Gender_{it} + \beta_3 Race_{it} + \beta_4 Education_{it} + \beta_5 Income_{it} \\
+ \beta_6 MaritalStatus_{it} + \beta_7 EmploymentStatus_{it} + \beta_8 PartyID_{it} \\
+ \beta_9 PartyID \times Ideology_{it} \quad + \delta_{it} + \gamma_{it} + \epsilon_{it}
\end{aligned} \tag{2}
$$

4 Results

Even purely descriptive patterns linking an outcome with both age and cohort in time-series cross sectional data are challenging due to an "impossible trinity" stemming from multicollinearity. Put simply, age and generational cohort are increasingly multicollinear with each other as the panel shrinks. Relatedly, even with a longer panel in which we can observe sufficiently uncorrelated variation between age and cohort, year fixed effects are impossible if we want to include both age and cohort together.

Thus we begin our analysis with purely descriptive visualizations of our data, plotting age on the x-axis, concern on the y-axis, and probing the impossible trinity of age, cohort, and year. The left panel of Figure 5 suggests that there is a negative association between age and climate concern, aggregating over all years of the data. However, disaggregating by generation in the center panel reveals that this conclusion is spurious, and that the association between age and concern is in fact positive across all generations, although only mildly so for the Silent generation. Finally, the right-most panel demeans concern by year, further complicating our story. Here we find that the association between age and concern is positive for the youngest two cohorts, but is then negative for older generations, suggesting that the patterns in the center panel are themselves spurious reflections of an overtime increase in concern. Furthermore, demeaning by year suggests that generational differences are minimal, with 70 year old members of the silent generation only being slightly less concerned than 70 year old Boomers.

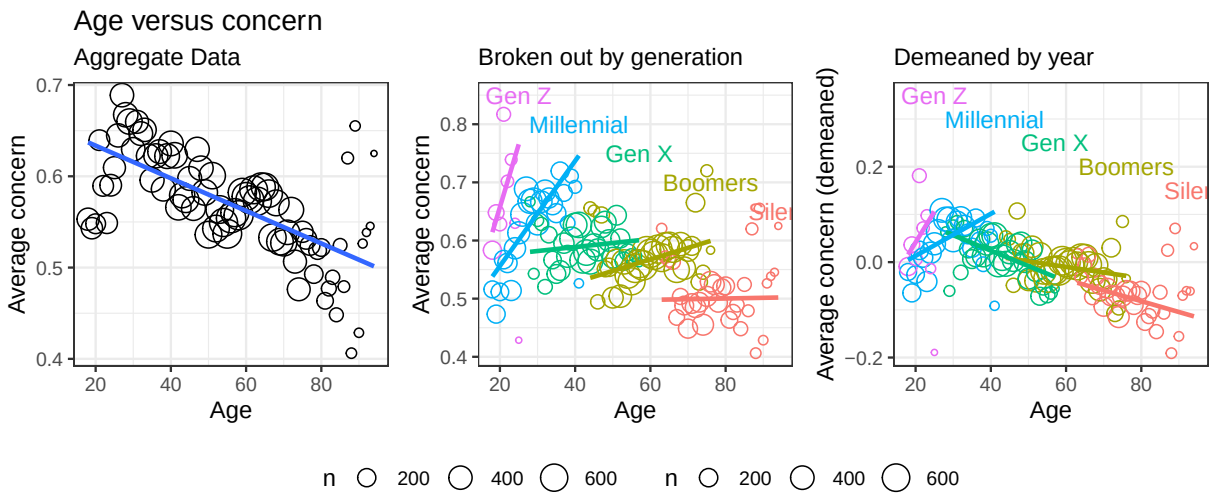

Figure 5: Descriptive visualizations of the relationship between age, generation, and concern. The left panel aggregates over all generations and years to suggest a negative relationship. The center panel disaggregates by generation, suggesting that the relationship is in fact positive. The right panel demeans concern by year, suggesting that the relationship is positive only for the youngest two cohorts, before becoming negative for older generations.

The preceding plot suggests that older people are less worried about climate change, although this conclusion depends on the generational cohort. However, one crucial omitted variable requires investigation: partisanship. We visualize the association between age and generation by partisanship in Figure 6, using the annually de-meaned version of the concern measure as the y-axis of interest. As illustrated, there is evidence that the relationship between concern and age depends on party affiliation, with Democrats being the only group who consistently grows more concerned as they age within generational cohorts, but also the group among whom the overall relationship is effectively zero.

4.1 Concern and Age

The preceding visualizations are useful roadmaps to the analyses that follow. Importantly, while alternative explanations of generation, year, and partisanship appear to matter, a curvelinear shape persists in which the youngest members of the data grow more concerned

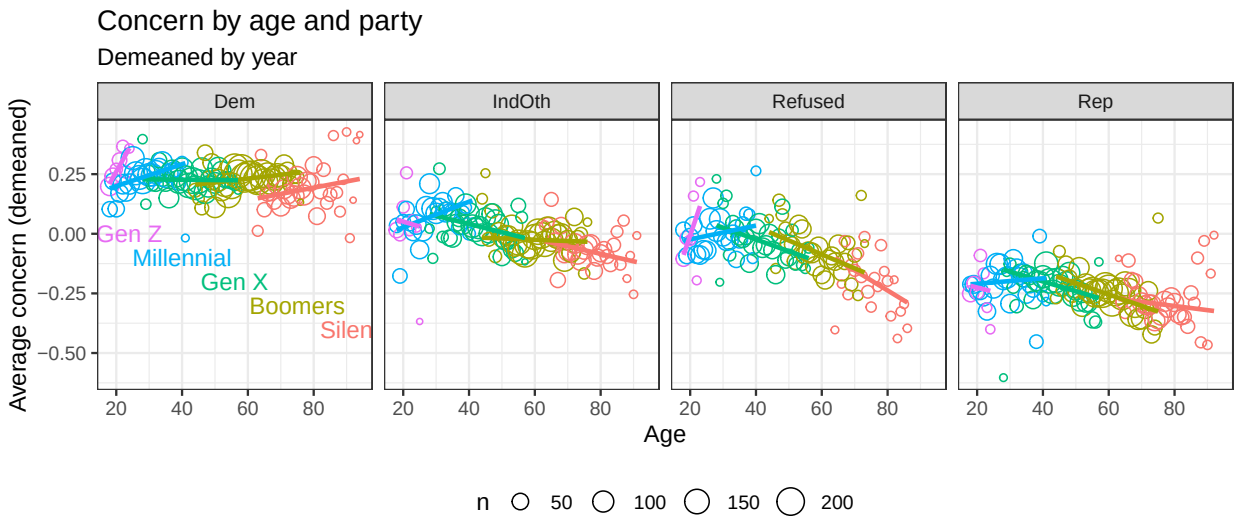

Figure 6: Descriptive visualizations of the relationship between age, generation, and annually-demeaned concern, broken out by partisanship (facets).

as they grow up to roughly their 30s, after which the relationship between concern and age turns negative over the rest of an individual's lifetime. But are these patterns statistically significant? We start by predicting overall concern with climate change as a function of age along with a battery of other sociodemographic and political covariates. We present these results in Table 1, adding additional covariates as we move left to right across columns. As illustrated, the coefficient on the age of the respondent is consistently negative, indicating that a 1 standard deviation increase in age (roughly 17 years) corresponds to approximately a 0.02 decline in concern. Substantively, even if we translate this into a shift from an 18 year old to a 90 year old, it still amounts to only 5 percentage points less concerned, a magnitude commensurate to other demographic and economic covariates, but only a fraction of the size of the coefficients on partisanship and ideology. Nevertheless, that this relationship persists even with the inclusion of party affiliation is noteworthy, given the abundant and increasing evidence of political polarization in climate change beliefs [Egan and Mullin, 2017, 2024, Druckman and McGrath, 2019].

As theorized above, the relationship between concern and age is consistent with one of two broad explanations. First, there might be a connection between one's time spent on earth

Table 1: Concern about global warming by age

Model:	Bivariate (1)	+Demog Ctrls (2)	+Econ Ctrls (3)	+Party (4)	+Party X Ideo (5)
Variables					
Age: 1SD (17 yrs)	-0.0351***	-0.0267***	-0.0125**	-0.0227***	-0.0121**
	(0.0040)	(0.0038)	(0.0053)	(0.0047)	(0.0041)
Gender: Female		0.0781***	0.0762***	0.0626***	0.0507***
		(0.0055)	(0.0061)	(0.0054)	(0.0047)
Race: Black, Non-Hisp		0.0997***	0.0737***	-0.0653***	-0.0785***
		(0.0160)	(0.0142)	(0.0121)	(0.0106)
Race: Other, Non-Hisp		0.0994***	0.0957***	0.0549***	0.0454***
		(0.0122)	(0.0137)	(0.0128)	(0.0127)
Race: Hispanic		0.1561***	0.1495***	0.0840***	0.0742***
		(0.0112)	(0.0128)	(0.0102)	(0.0106)
Educ: High school		-0.0180	-0.0076	-0.0086	-0.0050
		(0.0109)	(0.0114)	(0.0123)	(0.0126)
Educ: Some college		0.0091	0.0191*	0.0173	0.0218**
		(0.0087)	(0.0092)	(0.0098)	(0.0095)
Educ: Bachelor+		0.0768***	0.0912***	0.0617***	0.0532***
		(0.0099)	(0.0108)	(0.0103)	(0.0101)
Marital: Single			0.0505***	0.0149	0.0032
			(0.0129)	(0.0099)	(0.0086)
Marital: Wid, Div, Sep			0.0394***	0.0211**	0.0071
			(0.0090)	(0.0073)	(0.0083)
Marital: Partner			0.1512***	0.1018***	0.0745***
			(0.0104)	(0.0087)	(0.0093)
Emp: Not working			-0.0145	-0.0131	-0.0100
			(0.0087)	(0.0085)	(0.0079)
Emp: Unemployed			0.0044	-0.0015	-0.0040
			(0.0154)	(0.0149)	(0.0150)
Income: 1SD (5 units)			-0.0062	-0.0017	-0.0004
			(0.0040)	(0.0036)	(0.0029)
PID: Indep				-0.1834***	
				(0.0104)	
PID: Refused				-0.2336***	
				(0.0173)	
PID: Rep				-0.4069***	
				(0.0146)	
PID X Ideo: Refused					0.0259
					(0.0282)
PID X Ideo: Lib Dem					0.2857***
					(0.0176)
PID X Ideo: Moderate/Cons Dem					0.1657***
					(0.0238)
PID X Ideo: Indep					-0.0121
					(0.0162)
PID X Ideo: Moderate Rep					-0.0318**
					(0.0138)
PID X Ideo: Cons Rep					-0.3022***
					(0.0194)
Fixed-effects					
Year	Yes	Yes	Yes	Yes	Yes
Census Region	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	30,053	30,053	26,992	26,992	26,992
R^2	0.02612	0.05020	0.05283	0.14227	0.20599
Within R^2	0.00547	0.03005	0.03474	0.12590	0.19083

Clustered (Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

and their views on climate change, due either to temporal discounting or to the subjective perception of time's passage. Second, age might merely proxy for a respondent's socialization, wherein older respondents grew up in an information environment that was less concerned about climate change. To investigate this question, we first re-run our main specification replacing age (in years) with a categorical measure of generation, defined by the respondent's birth year. As illustrated in Table 2, our main conclusions persist and are strengthened with this approach. (We omit the non-political controls for visual clarity.) Furthermore, we underscore that the coefficients are monotonically increasing with each subsequent generation and are of substantively meaningful magnitudes, although acknowledge that these estimates are still only fractions of the largest coefficients found for political predictors.

The preceding results thus find evidence that age and generation both matter, although we are unable to jointly test them while also implementing year fixed effects to soak up the overtime changes in public attitudes on climate change. Instead, we run the full specification including both generation and age, as well demographic, economic, and party controls, in three different ways. First, we estimate the regression without any adjustment for overtime changes ("Vanilla" column in Table 3). As illustrated, concern is increasing for each generation dummy as well as for age, reflecting the secular increase in concern found in the data. Second, we estimate the regression on a year-demeaned version of the outcome. While not equivalent to implementing year fixed effects, this nevertheless removes the secular trend from the year waves. Here, we find that the coefficient on age is now negative, and of a similar magnitude to that documented above, while the coefficients on generation are no longer monotonically increasing with each subsequent generation and are only about half the magnitude found above. Finally, we estimate the regression using a quadratic polynomial trend on year to soak up secular variation over time. As before, the coefficient on age remains negative and statistically significant.

Table 2: Concern about global warming by generation

Model:	Bivariate (1)	+Demog Ctrls (2)	+Econ Ctrls (3)	+Party (4)	+Party X Ideo (5)
Variables					
Gen: Boomers	0.0714***	0.0582***	0.0577***	0.0585***	0.0448***
	(0.0101)	(0.0110)	(0.0121)	(0.0108)	(0.0106)
Gen: Gen X	0.1002***	0.0701***	0.0624***	0.0771***	0.0498***
	(0.0123)	(0.0137)	(0.0164)	(0.0139)	(0.0117)
Gen: Millennial	0.1295***	0.0987***	0.0650***	0.0842***	0.0512***
	(0.0127)	(0.0121)	(0.0192)	(0.0173)	(0.0156)
Gen: Gen Z	0.1221***	0.1116***	0.0635*	0.0898**	0.0628**
	(0.0279)	(0.0271)	(0.0353)	(0.0313)	(0.0283)
PID: Indep				-0.1826***	
				(0.0106)	
PID: Refused				-0.2334***	
				(0.0176)	
PID: Rep				-0.4060***	
				(0.0147)	
PID X Ideo: Refused					0.0270
					(0.0285)
PID X Ideo: Lib Dem					0.2856***
					(0.0178)
PID X Ideo: Moderate/Cons Dem					0.1653***
					(0.0239)
PID X Ideo: Indep					-0.0123
					(0.0162)
PID X Ideo: Moderate Rep					-0.0316**
					(0.0140)
PID X Ideo: Cons Rep					-0.3018***
					(0.0197)
Controls	None	Demogs	Econ	Party	PID x Ideo
Fixed-effects					
Year	Yes	Yes	Yes	Yes	Yes
Census Region	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	30,053	30,053	26,992	26,992	26,992
R^2	0.02659	0.05048	0.05361	0.14272	0.20636
Within R^2	0.00594	0.03034	0.03554	0.12636	0.19121

Clustered (Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

4.2 Curvelinear Associations

The preceding patterns find that concern about global warming is negatively associated with age, measured either as the respondent's nominal age in years or as one's generational cohort. On its own, this conclusion is consistent with the rational utility model of discounting, wherein older respondents are less materially impacted by climate change and are thus less concerned. However, the preceding results' reliance on linear probability models precluded

Table 3: Concern about global warming by generation and age

Model:	Vanilla (1)	Demeaning by Year (2)	Quadratic Trend for Year (3)
Variables			
Gen: Boomers	0.0998***	0.0418***	0.0418**
	(0.0180)	(0.0113)	(0.0144)
Gen: Gen X	0.1575***	0.0430**	0.0424*
	(0.0344)	(0.0155)	(0.0225)
Gen: Millennial	0.2029***	0.0343	0.0338
	(0.0512)	(0.0262)	(0.0369)
Gen: Gen Z	0.2623***	0.0292	0.0331
	(0.0659)	(0.0305)	(0.0368)
Age: 1SD (17 yrs)	0.0385**	-0.0183**	-0.0184*
	(0.0170)	(0.0068)	(0.0094)
PID: Indep	-0.1818***	-0.1829***	-0.1837***
	(0.0099)	(0.0105)	(0.0104)
PID: Refused	-0.2373***	-0.2344***	-0.2349***
	(0.0171)	(0.0174)	(0.0174)
PID: Rep	-0.4047***	-0.4062***	-0.4067***
	(0.0142)	(0.0146)	(0.0147)
Controls	Full	Full	Full + Quadratic Trend
Fixed-effects			
Census Region	Yes	Yes	Yes
Fit statistics			
Observations	26,992	26,992	26,992
R^2	0.13491	0.13382	0.14124
Within R^2	0.12752	0.12645	0.13390

Clustered (Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

our ability to test whether the association between age and concern is curvelinear. As per hypothesis H2.b, endogenizing an individual's discount factor or the costs of climate change to their age might produce U-shaped relationships in which concern first decreases with age but then increases.

To test, we re-run our main specification but model age with a quadratic polynomial, allowing us to characterize the shape of the association. As above, we demean the outcome by year and include generation dummies as controls. We visualize these results in the left panel of Figure 7 which plots the predicted margins across the support of age, revealing – if anything – an inverted U-shape association between age and concern. Both the base and squared terms of the polynomial are statistically significant at the 99% level, while the

generation dummies are consistently null (albeit positive). But when we re-run the same specification with a cubic polynomial, we start to see evidence consistent with the theoretical expectation that the oldest respondents are more concerned about global warming (right panel of Figure 7). The coefficients on the cubic terms are all statistically significant at the 99% level, although as visualized, the uptick in concern does not occur until respondents reach their early 80s.

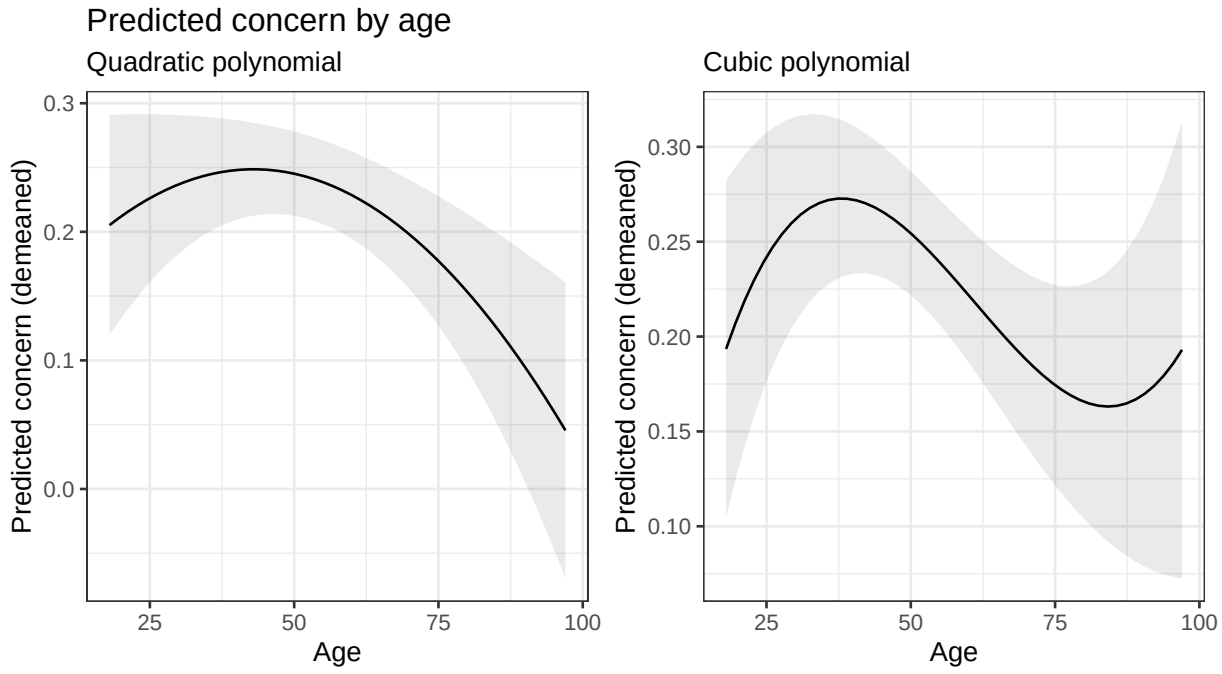

Figure 7: Predicted concern (demeaned by year) by a quadratic polynomial fit for age (left panel) and a cubic polynomial (right panel). Specifications control for all covariates including generation dummies, and demean the outcome by year. All polynomial terms are statistically significant at the 99% level.

4.3 Dimensions of Concern

The main results robustly demonstrate that (1) age is an important but previously overlooked predictor of attitudes on climate change, (2) older respondents are generally less concerned, even after controlling for generational cohort and demeaning the outcome variable by year, and (3) there is some evidence of a curvelinear shape, although the theorized

U-shape manifests later in life. While broadly consistent with hypotheses 1 and 2.b, we are unsure whether elements of the more nuanced theories such as endogenous risk preferences, costs of climate change, or the utility function itself explain these patterns. To test, we turn to other outcomes found in the data.

First, we examine variation across four questions about the harms caused by global warming. We interpret the relationship between respondent age and their belief that global warming will harm them personally as evidence that speaks to endogenous costs of climate change. If older respondents either perceive the projected onset of global warming to be nearer due to their subjective perceptions of time, or more costly due to their greater vulnerability, we would expect to see a positive association between this measure and age. We interpret the relationship between respondent age and their belief that global warming will harm future generations as evidence that speaks to the intergenerational loyalty, or sociotropism found in the education literature. If older respondents incorporate future generations' utility into their own attitudes on global warming, we should see them be more aware of possible harms to these groups. Relatedly, we also look at the relationship between age and perceptions of harm to the United States, and harm to developing countries. Here, sociotropism is defined not across time but across space. As above however, if this other-regarding component of one's utility is increasing with age, we should see greater evidence of these attitudes among older respondents. As illustrated in Figure 9, we find suggestive evidence in support of perceptions of personal harm, and harm to the United States increasing among the oldest respondents, although only the former is statistically significant. Meanwhile there is no evidence to support the intergenerational loyalty theory, and similarly no evidence that sociotropism might apply more widely than the US.

Second, to investigate the possibility that there are differences in an individual's discount factor due to age, we turn to a question that asks respondents to indicate when global warming will start to harm people in the US. Possible responses include never, 100, 50,

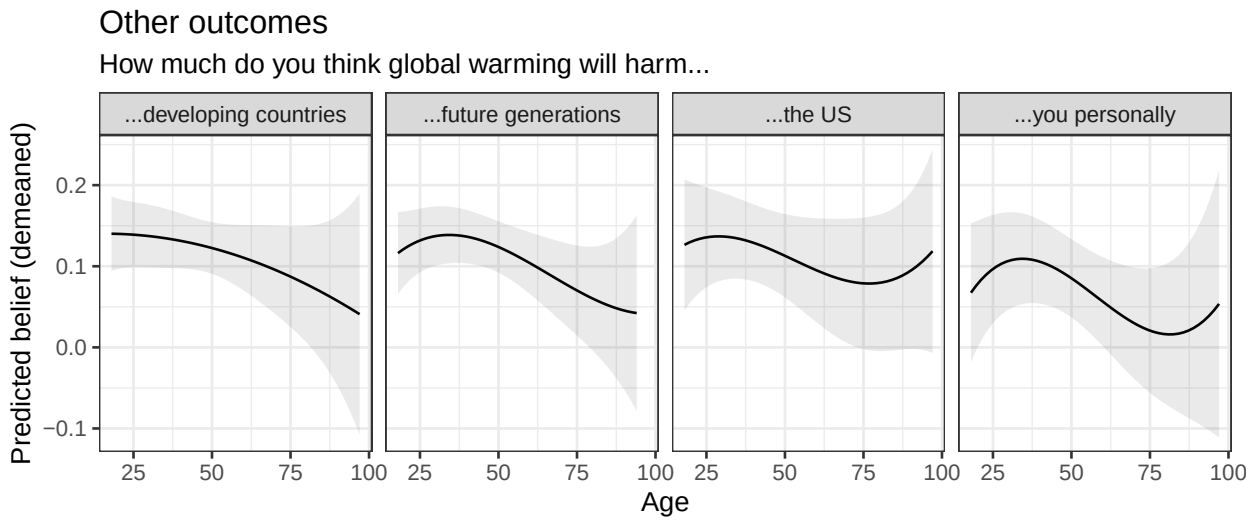

Figure 8: Belief in different types of harms caused by global warming (demeaned by year, panels) predicted by a cubic polynomial fit for age. Specifications control for all covariates including generation dummies, and demean the outcome by year. Only the polynomial terms on personal harm are statistically significant at the 90% threshold.

25, or 10 years, or that they are being harmed right now. Here we find evidence of older respondents believing that this will happen sooner than younger, although the third term in the cubic polynomial is only significant at the 90% level (see Figure **??**). Nevertheless, this pattern is consistent with the theory that older individuals either discount the future less than younger, or that their subjective perception of time is different.

4.4 Mechanisms

The preceding results were framed with respect to a rational self-interest story in which age exhibits an independent and negative association with concern about climate change and beliefs about its harms, while there is a positive association linking age and how soon the individual expects people in the US to be harmed. Analysis of cubic polynomials found modest evidence consistent with a more nuanced theory in which the youngest and oldest respondents are more concerned, and more believing in the harms. Nevertheless, these descriptive correlations cannot rule out an alternative explanation in which information

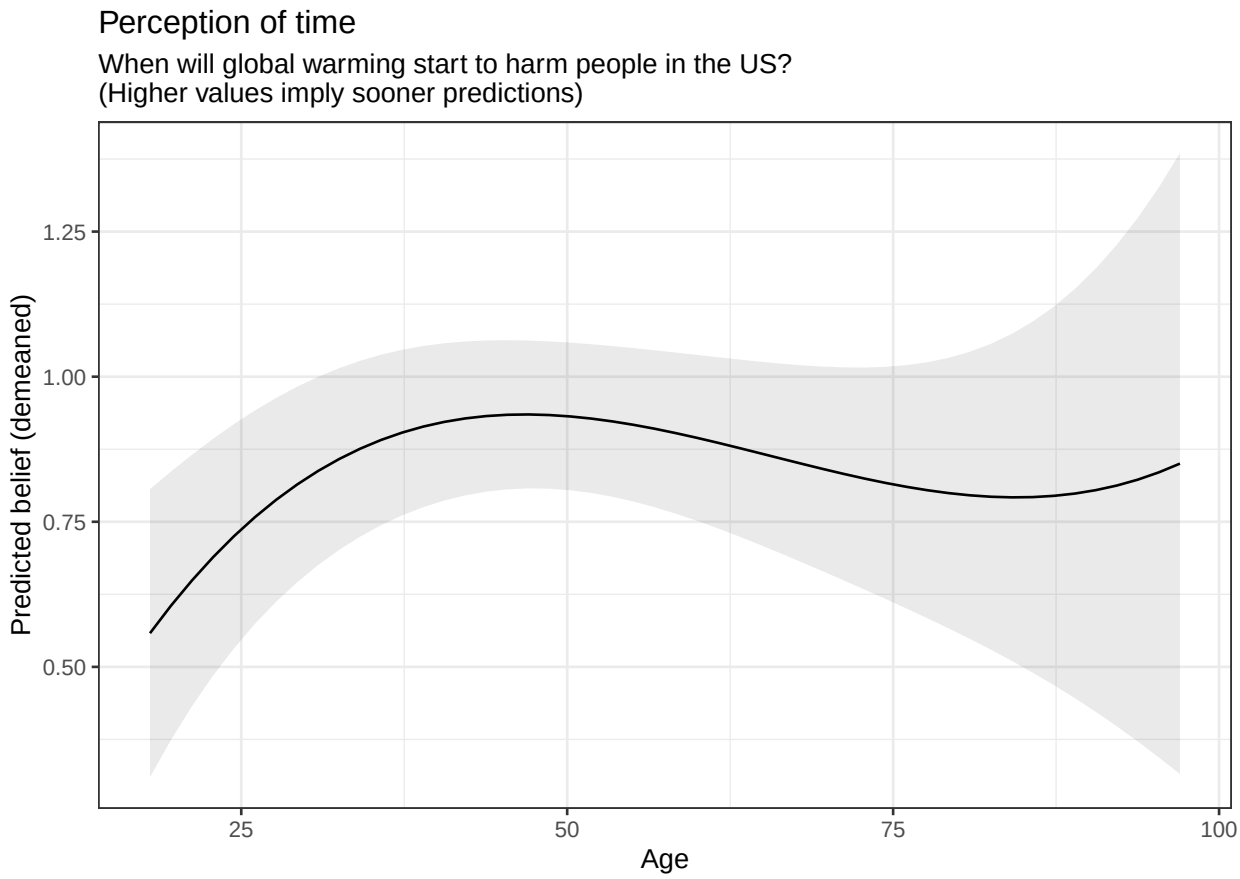

Figure 9: Relationship between respondent's age and response to when they believe global warming will harm the US. Higher values indicate belief that the US will be harmed sooner.

about climate change covaries with age. In particular, one might imagine that recent younger people are more aware of climate change in their social networks. In this setting, we conceive of information as the causal agent and age as the moderator.

To investigate this explanation, we predict attitudes on climate as a function of age interacted with the respondent's self-reported exposure to media coverage of global warming. Clearly, while the preceding associations were not causally identified, we must proceed with even greater caution when regressing one survey self-reported measure on another. It is possible that those who are more concerned about global warming will also report hearing about it more on the news as a way to justify the concern. With these caveats in mind, we present the following results as suggestive empirical patterns warranting further analysis.

Writ large, there is a positive relationship between self-reported exposure to media coverage of global warming, which exhibits a mild U-shaped relationship with age (left panel of Figure 10). On its own, this might be consistent with the explanation that younger people are simply more exposed to information about climate change, and that it is this information which drives their attitudes. Yet as we demonstrate in the right panel of Figure 10, reported exposure to media coverage of global warming is *increasing* in age, with the median age of respondents reporting the lowest exposure being roughly 40, while the median age of those reporting the highest exposure being almost 60.

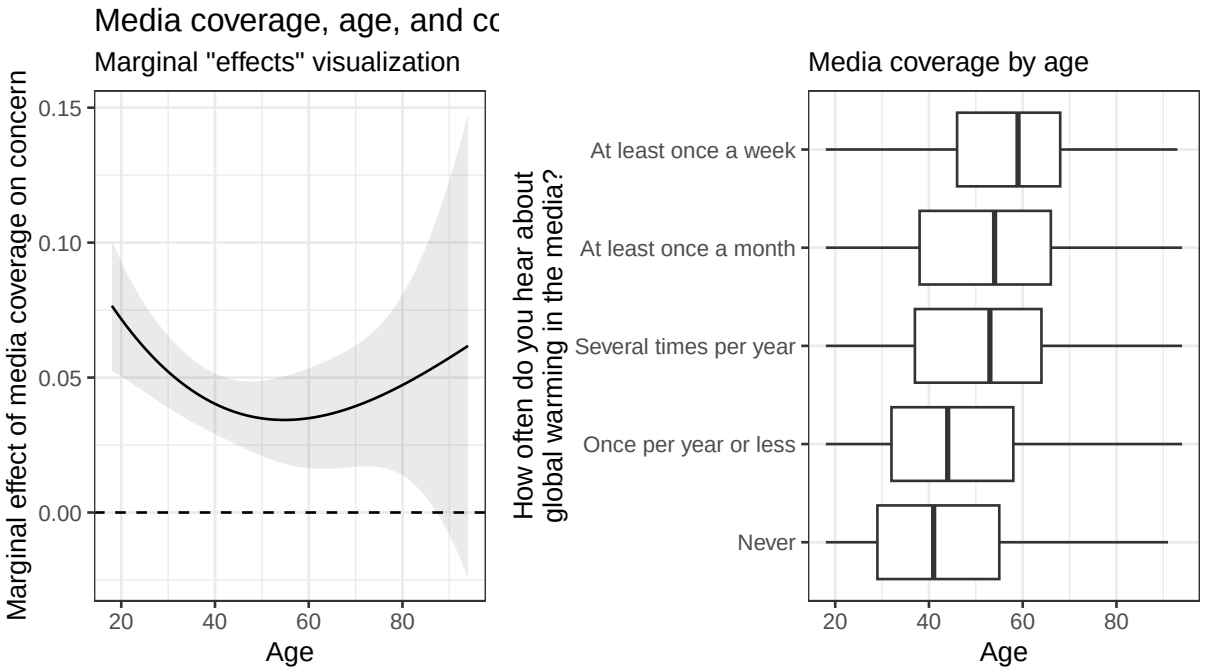

Figure 10: Marginal association between media coverage of global warming and concern about global warming (left panel). Distribution of exposure to media coverage of global warming by age (right panel).

While suggestive, the above patterns suggest that the relationship between media coverage of global warming and attitudes are unlikely to explain the broader patterns we see with respect to age. However, media coverage is a poor proxy for the broader environment in which we expect information about climate change to manifest, especially for younger individuals who pay less attention to the news. As a final test, we re-run the same analysis

used for the media coverage on a self-reported measure of how often the respondent discusses global warming with family and friends. The caveats applied to the self-reported media coverage are even more crucial to keep in mind here, as this measure skirts dangerously close to simply being a different proxy of the same latent measure we estimate with our concern outcome.

The results appear to be quite similar to the self-reported media coverage, with the obvious difference that the association between self-reported discussions and concern is positive and highly statistically significant across all ages. Perhaps surprisingly, we note the monotonically increasing relationship between discussing global warming and respondent age, although also note that the differences are much smaller, ranging from about 51 to 57 years at the median. Nevertheless, in contrast to the presumption that younger individuals live in information environments where global warming is commonly discussed, these data indicate the opposite.

5 Conclusion

As we progress towards an inevitably disrupted future due to climate change, age becomes more closely linked with experiencing the tangible and more severe consequences of these changes. How these anticipated consequences influence politically significant beliefs is an area of inquiry that we have investigated in this study.

What is the relationship between age and climate change attitudes? Overall, our descriptive results suggests that concern decreases as age increases, even when controlling for partisanship, in line with our first hypothesis. However, we also find evidence of a curvilinear relationship that manifests later in life. Both young and old individuals are the most concerned, which supports our hypothesis 2.b. On the other hand, generations or birth cohorts don't seem to matter that much for public opinion on climate change attitudes.

Diving into the dimensions of concern or risk perceptions, we find mixed results. Older participants are more concerned about global warming harming them personally, but they are not more concerned about developing countries or future generations. Older participants also believe global warming will harm the people in the United States sooner than younger participants, which suggests that age influences how an individual discounts the future or perceives time.

While acknowledging data limitations, we account for the influence of the information environment and find a positive relationship between concern and self-reported media exposure and a mild curvilinear relationship with age. The results also show that younger people are not necessarily more informed about climate change. Both self-reported media exposure and self-reported discussing with friends actually increase with age.

Taken together, our findings highlight new research opportunities to more carefully unpack how views on the climate are influenced by age. The answers to these questions matter both for the specific issue of climate change, a vital threat to public welfare whose solutions are inherently political in nature; and for belief formation as a function of age writ large.

References

C. H. Achen. Social psychology, demographic variables, and linear regression: Breaking the iron triangle in voting research. *Political behavior*, 14:195–211, 1992.

L. M. Bartels. Messages received: The political impact of media exposure. *American political science review*, 87(2):267–285, 1993.

L. F. Beiser-McGrath and R. A. Huber. Assessing the relative importance of psychological and demographic factors for predicting climate and environmental attitudes. *Climatic change*, 149:335–347, 2018.

A. Bejan. Why the days seem shorter as we get older. *European Review*, 27(2):187–194, 2019.

M. B. Berkman and E. Plutzer. Gray peril or loyal support? the effects of the elderly on educational expenditures. *Social Science Quarterly*, 85(5):1178–1192, 2004.

R. A. Block, D. Zakay, and P. A. Hancock. Human aging and duration judgments: a meta-analytic review. *Psychology and aging*, 13(4):584, 1998.

T. J. Blocker and D. L. Eckberg. Gender and environmentalism: Results from the 1993 general social survey. *Social Science Quarterly*, pages 841–858, 1997.

S. S. Bush and A. Clayton. Facing change: Gender and climate change attitudes worldwide. *American Political Science Review*, 117(2):591–608, 2023.

L. L. Carstensen. The influence of a sense of time on human development. *Science*, 312 (5782):1913–1915, 2006.

J. N. Druckman and M. C. McGrath. The evidence for motivated reasoning in climate change preference formation. *Nature Climate Change*, 9(2):111–119, 2019.

P. J. Egan and M. Mullin. Turning personal experience into political attitudes: The effect of local weather on americans' perceptions about global warming. *The Journal of Politics*, 74(3):796–809, 2012.

P. J. Egan and M. Mullin. Climate change: Us public opinion. *Annual Review of Political Science*, 20:209–227, 2017.

P. J. Egan and M. Mullin. Us partisan polarization on climate change: Can stalemate give way to opportunity? *PS: Political Science & Politics*, 57(1):30–35, 2024.

A. Franzen and D. Vogl. Two decades of measuring environmental attitudes: A comparative analysis of 33 countries. *Global Environmental Change*, 23(5):1001–1008, 2013.

P. S. Hart and E. C. Nisbet. Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Communication research*, 39(6):701–723, 2012.

C. Hazlett and M. Mildenberger. Wildfire exposure increases pro-environment voting within democratic but not republican areas. *American Political Science Review*, 114(4): 1359–1365, 2020.

M. J. Hornsey, E. A. Harris, P. G. Bain, and K. S. Fielding. Meta-analyses of the determinants and outcomes of belief in climate change. *Nature climate change*, 6(6):622–626, 2016.

C. E. Löckenhoff. Age, time, and decision making: From processing speed to global time horizons. *Annals of the New York Academy of Sciences*, 1235(1):44–56, 2011.

A. Malka, J. A. Krosnick, and G. Langer. The association of knowledge with concern about global warming: Trusted information sources shape public thinking. *Risk Analysis: An International Journal*, 29(5):633–647, 2009.

J. R. Marlon, X. Wang, M. Mildenberger, P. Bergquist, S. Swain, K. Hayhoe, P. D. Howe, E. Maibach, and A. Leiserowitz. Hot dry days increase perceived experience with global warming. *Global Environmental Change*, 68:102247, 2021. ISSN 0959-3780. doi: https://doi.org/10.1016/j.gloenvcha.2021.102247. URL `https://www.sciencedirect.com/science/article/pii/S0959378021000261`.

A. M. McCright, C. Xiao, and R. E. Dunlap. Political polarization on support for government spending on environmental protection in the usa, 1974–2012. *Social science research*, 48: 251–260, 2014.

D. Read and N. L. Read. Time discounting over the lifespan. *Organizational behavior and human decision processes*, 94(1):22–32, 2004.

K. L. Seaman, S. J. Abiodun, Z. Fenn, G. R. Samanez-Larkin, and R. Mata. Temporal discounting across adulthood: A systematic review and meta-analysis. *Psychology and Aging*, 37(1):111, 2022.

P. D. Sozou and R. M. Seymour. Augmented discounting: interaction between ageing and time–preference behaviour. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 270(1519):1047–1053, 2003.

P. A. Trostel and G. A. Taylor. A theory of time preference. *Economic inquiry*, 39(3): 379–395, 2001.

S. Van der Linden. Determinants and measurement of climate change risk perception, worry, and concern. *The Oxford Encyclopedia of Climate Change Communication. Oxford University Press, Oxford, UK*, 2017.

P. Verhaeghen and J. Cerella. Aging, executive control, and attention: A review of meta-analyses. *Neuroscience & Biobehavioral Reviews*, 26(7):849–857, 2002.

B. D. Wood and A. Vedlitz. Issue definition, information processing, and the politics of global warming. *American journal of political science*, 51(3):552–568, 2007.

M. J. Zechman. Dynamic models of the voter's decision calculus: Incorporating retrospective considerations into rational-choice models of individual voting behavior. *Public Choice*, 34(3):297–315, 1979.