

Growing importance of climate change beliefs for attitudes towards gas

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Tense global politics, spikes in gas prices and increasingly urgent warnings about climate change raise questions over the future use of natural gas. UK longitudinal survey data reveal that beliefs about climate change increasingly reduced support for gas extraction between 2019 and 2022. Mounting public connections between climate and gas use suggest growing opportunities for climate communication to lower support for all fossil fuels, not just the more carbon-intensive oil and coal.

Russia's invasion of Ukraine and continued war there has led to massive political and public pressure worldwide to rethink energy security. The European Union has pledged to become entirely independent of Russian fossil fuels before 2030¹; the UK—which imports far less natural gas directly from Russia (4%)—has currently halted any imports of Russian oil and coal and seeks to become completely independent of Russian liquefied natural gas (LNG) as soon as possible². The USA has agreed to dramatically increase LNG exports to Europe to help reduce the heavy European dependence on Russia³.

The approaches to reducing Russian reliance, however, vary considerably: (1) speed up the transition to renewables (whilst electrifying heat and transport)^{4,5}, (2) increase nuclear energy for electricity production^{6,7}, (3) identify alternate, preferably domestic, sources of gas^{8,9}, (4) consider hydrogen as a methane substitute for heating and (5) reduce the need for energy by focusing on energy efficiency and behaviour change^{10,11}. Although the direction of travel is towards increased renewables long-term, near-term increases in domestic hydrocarbon production¹² and expanded infrastructure to accommodate LNG imports¹³ could frustrate timelines for emissions reductions identified in the IPCC Assessment Report 6 (ref. ¹⁴), locking in extraction and gas use for decades. Gas constituted 42% of overall inland energy consumption in the UK in 2020—the highest of any fuel. Replacing gas in electricity (for example, renewables, especially wind) seems more feasible in the short-term compared to the large role of gas in heating; domestic use accounts for 37% of UK gas consumption¹⁵.

In this changing energy landscape, with rising urgency of emissions reduction¹⁶, understanding the relationship between public views about natural gas extraction and climate change could help reveal how the public will respond to policies seeking to expand gas extraction in a carbon-constrained world. Prior research has offered conflicting assessments, with some findings showing little connection between beliefs about climate change and support for gas development¹⁷, whilst other findings point to strong relevance of climate change for informing attitudes towards gas extraction¹⁸. A recent US study reveals notable support for natural gas use as a 'bridge fuel' but opposition to some specific approaches for extracting gas, such as hydraulic fracturing¹⁹; this comes as other research questions the role of gas as a 'bridge fuel'²⁰ and highlights the increasing policy debates over the 'bridge fuel' status²¹. The UK is currently heavily reliant upon gas for electricity production (36% of production in 2020—the highest from any source, followed by wind at 24%)¹⁵ and heat (74% of all heating and hot water demand in buildings from gas)²².

We conducted a longitudinal panel survey of a representative sample of 1,000 UK residents (Methods), surveyed in 2019, 2020, 2021 and 2022 examining their views on energy and climate issues. This allowed us to explore evolution in climate change beliefs, support for natural gas production and the relationship between these two. The dramatic increase in climate activism, in media, political and scientific attention to climate change and increased focus on the need to reduce use of all fossil fuels over this period^{23–26}, led us to hypothesize that

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Table 1 | Core survey items, mean values over time

	April 2019	June 2020	May 2021	May 2022
Offshore drilling in the North and Irish Seas (not using fracking)	5.07 ^a (n=872 ^b) (s.d.=1.14)	4.54 (n=890) (s.d.=1.35)	4.27 (n=867) (s.d.=1.45)	4.51 (n=901) (s.d.=1.54)
Traditional onshore drilling in the UK (not shale gas and not using fracking)	4.52 ^a (n=838) (s.d.=1.33)	4.16 (n=862) (s.d.=1.39)	3.99 (n=840) (s.d.=1.46)	4.24 (n=868) (s.d.=1.53)
Shale gas extraction onshore in the UK (using fracking)	3.02 ^a (n=823) (s.d.=1.78)	2.62 (n=866) (s.d.=1.65)	2.47 (n=857) (s.d.=1.61)	2.93 (n=884) (s.d.=1.79)
Seriousness of climate change for the UK as a whole ^c	3.50 ^c (n=938) (s.d.=1.15)	3.42 (n=946) (s.d.=1.10)	3.48 (n=935) (s.d.=1.12)	3.51 (n=943) (s.d.=1.09)
The evidence for climate change is unreliable ^d	2.59 ^d (n=891) (s.d.=1.63)	2.51 (n=911) (s.d.=1.61)	2.50 (n=896) (s.d.=1.64)	2.57 (n=898) (s.d.=1.69)
Political orientation ^e	3.81 ^e (n=1,000) (s.d.=1.38)	3.89 (n=1,000) (s.d.=1.38)	3.92 (n=1,000) (s.d.=1.37)	3.82 (n=1,000) (s.d.=1.40)
Read a print version of the <i>Daily Mail</i> in the last year	18% (n=1,000) (s.d.=0.38)	15% (n=1,000) (s.d.=0.36)	12% (n=1,000) (s.d.=0.33)	10% (n=1,000) (s.d.=0.30)
Read a print version of <i>The Guardian</i> in the last year	11% (n=1,000) (s.d.=0.32)	10% (n=1,000) (s.d.=0.30)	7% (n=1,000) (s.d.=0.26)	6% (n=1,000) (s.d.=0.24)

^aScale of 1–6: strongly oppose, moderately oppose, slightly oppose, slightly support, moderately support and strongly support. ^bThe sample sizes for 2019, 2020, 2021 and 2022 means are 1,000 minus ‘don’t know’ responses for that item. Although initial sample sizes were higher for waves 1, 2 and 3 (April 2019, June 2020 and May 2021), we use the sample from wave 4 (May 2022) for all means, to allow for systematic comparison across the panel data. ^cScale of 1–5: not at all serious, not very serious, fairly serious, very serious and extremely serious. ^dScale of 1–6: strongly disagree, moderately disagree, slightly disagree, slightly agree, moderately agree and strongly agree. ^eScale of 1–7: very liberal, liberal, slightly liberal, moderate, slightly conservative, conservative and very conservative.

climate change beliefs might increasingly shape views on natural gas production over time.

Our data reveal that support for domestic gas extraction clearly declines from 2019 to 2020, then again to 2021, but it increases somewhat in 2022 (Table 1). We asked about three types of gas extraction; support varied substantially across the different approaches to extraction but over time we observe similar patterns in how support changed for each type of gas extraction from one year to the next. For offshore drilling and traditional onshore drilling, this amounts to support waning in 2020 and 2021; for shale gas extraction, which consistently received far less support, opposition increases. Conversely, very little movement occurs in beliefs about climate change over time. Perceived seriousness of climate change differs slightly but significantly from Time 1 (T1) to T2 ($P = 0.033$) but not between T2 and T3, between T1 and T3, between T3 and T4 or between T1 and T4. Similarly, belief that the evidence for climate change is unreliable does not differ between any set of two time periods.

To explore how climate change beliefs affect support for gas production and whether this relationship changed over time, we estimated a set of latent growth models. Our first model (Methods), included only the three measures of natural gas support entered at each time (T1, T2, T3 and T4) and estimates of the intercept and slope means and variance. This model indicated an average reduction in support for natural gas extraction of 0.02 per month. This baseline model had adequate fit (root mean square error of approximation, RMSEA, = 0.070, comparative fit index, CFI, = 0.964, standardised root mean square residual, SRMR, = 0.061)²⁷.

We then included five time-varying predictors of support for natural gas extraction (political orientation, *Daily Mail* and *The Guardian* readership and two climate change beliefs) and two time-invariant covariates (age and sex) in a conditional growth model (Fig. 1 and Supplementary Table 1). The most interesting results come from the effect of climate change beliefs on support for gas extraction in the UK. At T1, neither perceived seriousness of climate change for the UK nor certainty of climate change has a significant effect on natural gas support (Fig. 1). Nevertheless, over time, the effect of climate change beliefs on gas support grows notably (unstandardized beta values grow from −0.02 to −0.09 to −0.12 to −0.16 for seriousness, and from 0.01 to 0.04 to 0.06 to 0.08 for unreliable science).

The T4 (year 2022) value for climate change seriousness (−0.16), for example, means that for every one-unit increase in perceived seriousness, gas support will decrease on average by 0.16 units. This is eight times larger an effect than in the 2019 data. Thinking that climate change is serious for the UK has an increasingly negative effect on support for gas extraction each year. Believing that climate science is unreliable has an increasingly positive effect on gas support (the converse is also true—believing that climate science is not unreliable has an increasingly negative effect on gas support).

It is unsurprising that support for natural gas extraction declined in the UK from 2019 to 2021 but then rose in 2022. High-profile events, such as the rise of climate action movements in the summer and autumn of 2019 (between T1 and T2) and then the public discourse in advance of the UK’s hosting of the 2021 United Nations Climate Change Conference COP26 (between T2 and T3) understandably drew attention to climate-related concerns about fossil fuel use²⁸. Climate consciousness has remained high, even with COVID-19 competing for attention^{28,29}. An influential IEA report³⁰ released in May 2021 (the same month as T3) states that a key milestone in the pathway to net zero by 2050 is no new oil and gas fields being approved for development as of 2021. Nevertheless, between T3 and T4, Russia’s invasion of Ukraine and the attendant spikes in gas costs fostered much rhetoric about the need for domestic energy security and for reliable sources of gas and oil in the UK.

Although support declined for the three forms of natural gas extraction that we asked about, even in May 2021 (the low point) the mean value was still approximately ‘slightly support’ for both offshore drilling and conventional onshore drilling (4 on a scale of 1–6). Shale gas extraction conversely fell to a level between slightly and moderately opposed (2020–2022).

The effect of climate change beliefs on support for gas extraction increased markedly. It is possible that the UK public has made clearer connections between gas extraction of all kinds and the detrimental effects of this energy source for climate change. Climate activism^{23–26} and even policy debates²⁰ have increasingly painted the status of gas as a transition fuel as problematic and have drawn attention to the role of gas in accelerating (rather than mitigating) climate change. For many years, gas was simultaneously presented as a fuel that could help climate action (for example, if substituted for coal) and as a fuel causing climate change (due to methane and CO₂ emissions).

Over the recent wave of climate action in Europe, that framing has been increasingly challenged; perhaps this contributed to the rising effect of climate beliefs on support for gas. Viewing gas as something bad for climate change does not necessarily mean, however, that people would perceive climate change as any more certain or serious; it merely highlights what may and may not be viable approaches for addressing climate change. This could explain how, even though climate change beliefs remained stagnant, the relationship between climate change beliefs and support for natural gas progressively strengthened. Support for gas has also become more polarized—with politics and left (*The Guardian*) versus right (*Daily Mail*) newspaper readership increasingly predicting support for gas over time (Fig. 1 and Supplementary Table 1).

The increasing effect of climate change beliefs on natural gas support has implications for public reactions to government policies

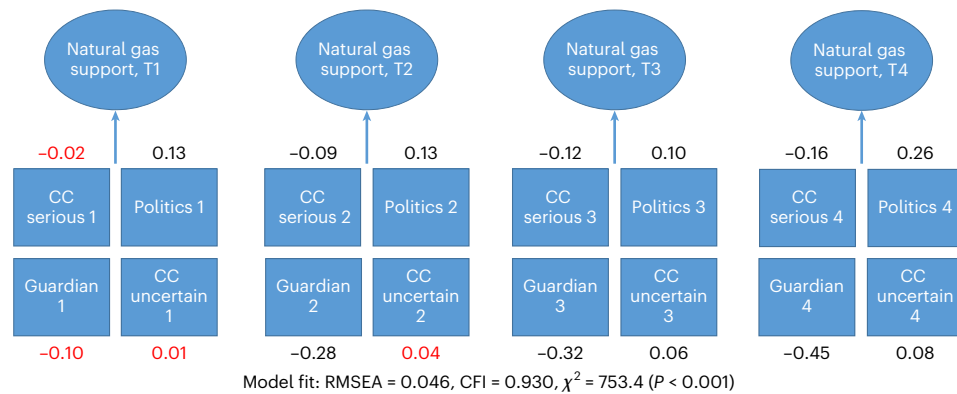


Fig. 1 | Conditional latent growth model. Note: coefficients in red are not statistically significant. CC, climate change.

that include a notable role for natural gas. This is particularly relevant with the publication in April 2022 of a new energy security strategy for the UK³¹ that opens up opportunities for expanded domestic gas production, stating ‘There is no contradiction between our commitment to net zero and our commitment to a strong and evolving North Sea industry’. Although the ‘evolving’ industry could include gas for hydrogen and using depleted fields for carbon sequestration, our data suggest a growing contradiction between domestic gas production and net zero in the minds of the UK public. The data also portend that if communication and activism efforts are able to negate the presumption of gas as a transition fuel and rather frame gas as a fossil fuel like any other, they could probably cause increased opposition to gas extraction.

In the quickly shifting global energy landscape following Russia’s war against Ukraine, some rhetoric/policy is strongly in favour of expanding renewables, some for nuclear, some for decreasing demand and some for new approaches to obtaining gas³². Our research suggests that, despite major geopolitical shifts over the last few years (for example, responses to the pandemic, effects of the Ukraine war), the link between climate change and gas has strengthened; climate change beliefs increasingly predict opposition to gas.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at <https://doi.org/10.1038/s41558-023-01622-7>.

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Methods

Data collection

The data come from four waves of a longitudinal survey of a representative sample of the UK general public, run in April 2019, June 2020, May 2021 and May 2022, administered by the online survey panel provider YouGov, via their own proprietary software. The survey was designed to measure public attitudes and responses to energy development in the UK. The first wave of the survey was constrained with quotas to represent the UK population on: age, sex, UK census region of residence, social grade, education, party vote in the 2017 general election, vote in the 2016 EU (Brexit) referendum and attention paid to politics. Although attrition occurred between waves, the samples varied little on the quota variables; only age differed notably (more attrition amongst younger respondents; mean age, as of 2019, for the samples was 49.4 years in wave 1, 53.0 years in wave 2, 54.5 years in wave 3 and 55.6 years in wave 4).

Respondents received incentive points from YouGov for their participation, which they could redeem for cash or prize entries. The 2,777 respondents to the initial survey were invited to a follow-up survey 14 months later, which attracted 1,858 respondents (67% from 2019). The respondents to the second survey were invited to another follow-up survey 11 months later, attracting 1,439 respondents (52% from 2019). Finally, of the wave 3 respondents, 1,000 responded 12 months later (36% from 2019).

Here, we examine change over time in support for natural gas extraction and the effect of climate change beliefs, political orientation, mass media consumption, age and sex on support for domestic gas extraction. Each variable was measured in all four surveys. Our dependent variable, in which we sought to model change over time, was a latent variable constructed from the following three measured items.

If the UK continues to use gas in the future to generate heat and electricity, to what extent do you support or oppose each of the following options for how we obtain that gas?

- Offshore drilling in the North and Irish Seas (not using fracking)
- Traditional onshore drilling in the UK (not shale gas and not using fracking)
- Shale gas extraction onshore in the UK (using fracking)

Response options included a 1–6 scale (strongly oppose, moderately oppose, slightly oppose, slightly support, moderately support and strongly support) and ‘don’t know’. Initial reliability scaling (Cronbach’s alpha) for the three forms of support of natural gas extraction revealed single constructs at each time ($\alpha = 0.71$ (T1), 0.73 (T2), 0.76 (T3) and 0.82 (T4)). We treated support for each of the three forms of gas extraction as a single latent variable due to: the reliability values, the fact that these three measures all conceptually capture the same broad concept of feelings towards gas extraction and their subsequent high factor loadings onto one latent variable in the confirmatory factor analysis (Fig. 1). Nevertheless, Table 1 reveals that the mean values differ substantially between shale gas extraction (fracking) and the other two forms of production. Both offshore and onshore extraction without fracking clearly enjoy majority support whilst shale gas extraction with fracking is subject to majority opposition.

The independent, predictor variables of support for UK gas extraction included:

- The respondents’ beliefs about how serious of a threat climate change poses to the UK as a whole (scale of 1–5, not at all serious to extremely serious, with ‘don’t know’ option)
- Beliefs about the extent to which the evidence for climate change is unreliable (scale of 1–6, strongly disagree to strongly agree, with ‘don’t know’ option)
- Political orientation (scale of 1–7, very liberal to very conservative)

- *Daily Mail* readership (read a print version in the last 12 months; yes/no)
- *The Guardian* readership (read a print version in the last 12 months; yes/no)
- Age (in years)
- Sex (male, female)

The *Daily Mail* and *The Guardian* were chosen to operationalize polarized media discourse on climate change, due to multiple studies showing very strong climate denial discourse in the *Daily Mail*—a highly read UK tabloid newspaper and the opposite from *The Guardian*—a left-ist broadsheet newspaper that focuses heavily on climate concerns^{33–35}. The *Daily Mail* constantly downplays need for action on climate change, whilst *The Guardian* constantly demands it. After excluding survey respondents with missing data and ‘don’t know’ responses, we had a final sample of $n = 963$ for our baseline latent growth model and $n = 737$ for our conditional growth model.

Each of the beliefs about climate change we included in our model were single-item measures. In our surveys, we included multiple indicators of perceived seriousness of climate change and of perceived certainty of anthropogenic climate change. We asked about seriousness of climate change for: you and your family, the UK as a whole, people in developing countries and wildlife and ecosystems. We then asked about agreement with statements that: claims about human activities changing the climate are exaggerated, the evidence for climate change is unreliable, climate change is just natural fluctuation of the Earth’s temperature and the media is often too alarmist about issues like climate change.

The results of exploratory factor analyses for the two sets of climate change beliefs in our survey are presented in Supplementary Table 2. The four measures of climate change seriousness and separately the four measures of anthropogenic climate change certainty, pooled very well onto single factors in all four waves of the longitudinal survey. To keep our conditional latent growth model parsimonious, however, we only included perceived seriousness of climate change as a threat to the UK in general and belief that evidence for climate change is unreliable, as the two metrics to represent these constructs in the final model. We considered the UK level most relevant to policy on both climate and natural gas. We chose unreliability as the construct most tied to uncertainty due to research showing questioning of evidence as a dominant discourse in the UK related to climate scepticism³⁶.

Data analysis

To investigate our hypothesis, we conducted two latent growth curve models designed to analyse change in support for natural gas extraction within our longitudinal survey sample. Curran et al.³⁷ define latent growth modelling as a set of ‘statistical methods that allow for the estimation of interindividual variability in intraindividual patterns of change over time’. The models fundamentally allow researchers to estimate differences in within-person change over time across a population.

We modelled latent growth via structural equation modelling (SEM), as opposed to via multilevel modelling, due to our inclusion of support for natural gas extraction as a latent variable constructed from three measured items. SEM has more capacity for incorporating comprehensive measurement models into latent growth modelling³⁷. We conducted initial analyses in SPSS (v.27) and then the latent growth model in Mplus (v.8.3).

Our first latent growth model was a baseline model in which we only included the three measures of support for gas production, collapsed onto a latent construct, at each of the four times the survey was run (T1, T2, T3 and T4). In this model we estimated the intercept mean (the starting point for support for gas extraction), slope mean (rate of change, per month, in support), intercept variance (degree of variability in the starting point across the survey respondents) and

slope variance (variability in the rate of change across respondents). Because the surveys were not in the same month each year, we used month rather than year in our latent growth models, with T1 being month zero, T2 month 14, T3 month 25 and T4 month 37.

Our second latent growth model was a conditional growth model, meaning we measured the intercept and slope means and variances again but whilst controlling for the effect of the aforementioned independent variables on support for gas extraction at each time. Age and sex were entered as time-invariant covariates because sex remains static for each respondent and age increases linearly with time. Climate change beliefs, *Daily Mail* and *The Guardian* readership and political orientation were entered as time-varying covariates, with unique values provided for each survey wave. Time-varying covariates speak to within-person influences, whilst time-invariant covariates speak to between-person influences³⁸.

Human subjects research

Human subjects approval for the survey research was granted by the Ethics Committees of the School of Social and Political Sciences at the University of Edinburgh and the Geography department at the University of Exeter. Informed consent was obtained from all research participants. All methods were performed in accordance with the relevant guidelines and regulations.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

The datasets used and analysed during the current study are available from the corresponding author upon reasonable request. The datasets were deposited with the UK Data Service and the UK's National Geoscience Data Centre in February 2023.

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Author contributions

D.E., L.W., P.D.W., J.D., P.B., M.B. and A.V. designed the surveys for data collection. D.E., L.W. and P.D.W. conducted the data analysis. All authors (D.E., L.W., P.D.W., J.D., P.B., C.F., M.B., S.R., A.M. and A.V.) contributed to writing the article and interpreting the results and implications of the findings. D.E., L.W., P.D.W., J.D., P.B. and M.B. collaborated on the application for the funding secured for this research.

Competing interests

The authors declare no competing interests.

Additional information

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Software and code

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Data collection YouGov used their own proprietary surveying software to conduct the survey (not a separately named software package). The responses were exported as an anonymised SPSS file (.sav).

Data analysis We used SPSS (version 27) and Mplus (version 8.3) to conduct our data analysis - SPSS for basic relationships and descriptive statistics, and Mplus for the latent growth curve modelling.

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The datasets used and analysed during the current study are available from the corresponding author upon reasonable request. The data sets will be deposited with the UK Data Service and the UK's National Geoscience Data Centre in February 2023.

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Study description	The data come from four waves of a longitudinal survey of a representative sample of the UK general public, run in April 2019, June 2020, May 2021, and May 2022 administered by the online survey panel provider YouGov. The survey was designed to measure public attitudes and responses to energy development in the UK. The data reported herein are all quantitative, mostly measured on Likert-type scales, but with ratio scale and dichotomous demographic covariates.
Research sample	The first wave of the survey was constrained with quotas to represent the UK population on: age, sex, UK census region of residence, social grade, education, party vote in the 2017 general election, vote in the 2016 EU (Brexit) referendum, and attention paid to politics. Therefore, this was a 'representative' sample based on the aforementioned variables. Although attrition occurred between waves, the samples varied little on the quota variables, leaving a mostly representative sample in wave 4 (the only deviation was that the sample remaining at wave 4 was somewhat older in profile than the UK). We chose a representative sample because the general population's views are most salient for questions of public policy direction and communication on climate change. This research was funded by UKRI as part of a grant examining UK populations.
Sampling strategy	The sample was randomly drawn from YouGov's online panel, with the constraint that it was selected to reflect the population values on the aforementioned quota variables. The data presented in this survey are from a 4-wave longitudinal survey. The initial sample size was chosen as a conservative estimate of what would allow for us to maintain a sample size of approximately 1000 in the fourth wave - three years later - due to attrition in the sample over time. We sought the 1000 size, due to seeking to conduct comparisons across socio-demographic and geographical groups within the survey.
Data collection	The survey was conducted online, via YouGov's panel and surveying software.
Timing	8-12 April 2019, 16-30 June 2020, 28 April - 16 May 2021, 23 May - 6 June 2022
Data exclusions	In reporting mean values, and running our multivariate data analysis (structural equation models), we treat 'don't know' responses on linear variables as missing data. All sample sizes are reported in the manuscript (Table 1). Between 0 and 177 missing data points existed for each of the 32 survey items reported (see Table 1). After excluding survey respondents with missing data and 'don't know' responses, we had a final sample of n=963 for our baseline latent growth model and n=737 for our conditional growth model.
Non-participation	The amount of respondents dropping out between waves of the survey is reported in the manuscript. For a four-wave longitudinal survey from an online panel, we consider the attrition as low as could be reasonably expected. We checked (and report in the methods section) the demographics of the final sample to the demographics of the initial representative sample. The 2,777 respondents to the initial survey were invited to a follow-up survey 14 months later, which attracted 1,858 respondents (67% from 2019). The respondents to the second survey were invited to another follow-up survey 11 months later, attracting 1,439 respondents (52% from 2019). Finally, of the wave 3 respondents, 1,000 responded 12 months later (36% from 2019).
Randomization	For the items reported on in this manuscript, respondents were not assigned to randomised groups.

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Population characteristics	See above for most details. The survey sample was constrained with quotas to represent the UK population on: age, sex, UK census region of residence, social grade, education, party vote in the 2017 general election, vote in the 2016 EU (Brexit) referendum, and attention paid to politics.
Recruitment	Participants were recruited by the recognised online panel provider YouGov. We contracted with YouGov for them to run the longitudinal survey with their panel, using their software.
Ethics oversight	Human subjects approval for the survey research was granted by the Ethics Committees of the School of Social and Political Sciences at the University of Edinburgh and the Geography department at the University of Exeter.

Note that full information on the approval of the study protocol must also be provided in the manuscript.