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Generational differences in climate-related beliefs, risk perceptions and emotions in the UK

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It is widely believed that younger generations are more engaged with climate change than older generations. However, evidence of a gap in climate-related perceptions and concern is mixed, likely due to the inconsistent use of outcome variables. Here we systematically examine generational differences across different types of climate engagement including cognitive and affective dimensions. Using data from three nationally-representative surveys conducted in the UK in 2020, 2021 and 2022, we show there is an overall pattern of higher levels of climate-related beliefs, risks perceptions and emotions among younger generation groups. However, the gap is larger and more consistent for climate-related emotions than for climate-related beliefs. While generational differences in climate-related emotions were found across all years, the overall gap has disappeared due to narrowing climate-related beliefs and risk perceptions. The generational differences are therefore mainly in emotional engagement rather than in beliefs about anthropogenic climate change.

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Research often shows that younger age groups are more concerned about climate change than older age groups[1–3]. This appears intuitive, given that younger age groups have grown up earlier hearing and learning about climate change and will be affected more by its consequences. The increased level of concern even goes beyond emotionally manageable levels as recent literature suggests. Evidence is growing that climate related anxiety is taking a toll on the wellbeing of children and young people, as they become aware of the threats posed by a heating planet[4–7]. The idea that there is a generation gap in engagement with climate change is further strengthened by young climate activists capturing the media's and public's attention[8,9].

There are however questions regarding the nature and the size of the generation gap, as effects have not been observed consistently. Age-related differences have been found in beliefs about the reality, causes, and impacts of climate change, with older individuals being more likely to express climate sceptical views than younger ones[3,10–12]; and there is evidence that younger people are more concerned about the environment in general[13,14] and climate change in particular[2,15]. Furthermore, younger age groups may be more likely to experience climate-related emotions, such as worry, anger and guilt[16], as well as climate-related anxiety[4]. However, other research only found small or absent age differences[17]. For example, Shi and colleagues (2016) report that age was not significant in explaining climate concern in five out of six countries; and a meta-analysis of research published between 1970 and 2010 concluded that age effects for environmental concern, values and commitment were negligible[18].

The mixed evidence regarding the nature and size of the generational gap may in part be due to methodological differences, and specifically because of the inconsistent use of outcome measures that suggest a similar comparison when they indeed express different levels of cognitive and affective engagement with the issue. Common variables used in previous studies include climate change beliefs, which are propositional cognitions about the nature of climate change that may or may not correspond with reality, and climate concern, which reflects an emotional state resulting from an affective evaluation of the seriousness of the impacts of climate change[3]. Risk perceptions as a related but different construct can be subdivided into perceived likelihood and seriousness, generalised concern, and personal worry[19]. Where perceived likelihood and seriousness are subjective cognitive evaluations of the risks and impacts of climate change, personal worry reflects a more experiential, emotional response to an uncertain and potentially dangerous future caused by the issue. Generalised concern is similarly experiential, but in contrast to worry can be expressed without motivational or emotional content[19]. That is, someone who is concerned about climate change may consider it a serious issue without experiencing feelings of tension or unease. In turn, worry and concern can be distinguished from the more intense emotions of fear[20–22], which is related to the fight-or-flight defence system[23], and anxiety[4,6], which is characterized by excessive and uncontrollable apprehension that can lead to psychological distress and physical symptoms. As such, climate fear and anxiety are potentially more debilitating and maladaptive than climate concern and worry[6,24]. Fig. 1 represents how the different constructs of climate-related beliefs, risk perceptions and emotions can be conceptually related to one another. This comprehensive model of climate engagement holds that the different cognitive and affective components of climate-related perceptions reflect different types and degrees of engagement with climate change, comprising cognitions about its nature (beliefs), subjective evaluation of its risks and consequences (risk perceptions), and the feelings it evokes (emotions). That is, the different climate-related components can be placed on a cognitive-affective dimensions, with the more
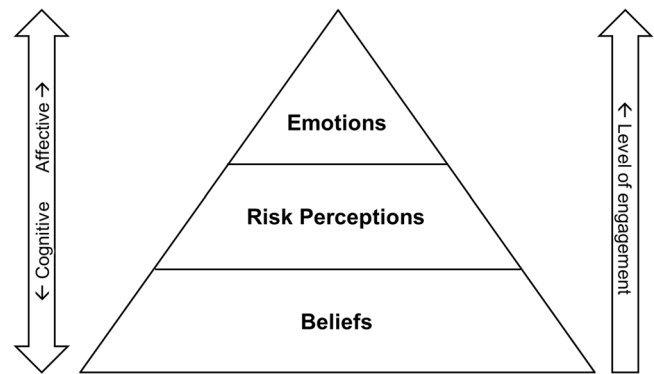

Fig. 1 Comprehensive model of climate engagement.

affective constructs reflecting a higher level of engagement with the issue. As suggested by Fig. 1, there is a hierarchical relationship between climate-related beliefs, risk perceptions and emotions. The lower components of the model are a necessary but insufficient condition for the higher components. While someone can recognise the reality of anthropogenic climate change, the person may not perceive it as a threat or experience any climate related emotions. On the other hand, in order to experience climate-related emotions, one has to believe that anthropogenic climate change is real and poses a threat. As such, it is important to clearly distinguish between the different components, as generational differences may exist for some but not for others.

Here, we explore generational differences across all these dimensions of climate engagement, using data from three cross-sectional nationally-representative surveys conducted in 2020, 2021 and 2022 in the United Kingdom (UK). The surveys contained a range of questions on beliefs regarding the causes, temporal proximity and urgency of climate change, as well as perceived impacts and threats, worry and other experienced emotions. The three cross-sectional surveys were analysed independently using the named groups based on the theory of generations, whereby different generations are shaped by shared experiences based on specific social and historical events and circumstances[25,26]. These generational labels help to draw together insights about different age cohorts over time, based on the assumption that those shared experiences lead to the formation of common values and opinions amongst the individuals[27]. The six named generations relevant to the analysis are the Post-War (or 'silent') generation (born between 1928 and 1945), the first half of the baby boomer generation (born between 1946 and 1954), the second half of the baby boomer generation (born between 1955 and 1964), Generation X (born between 1965 and 1980), Millennials (born between 1981 and 1996), and Generation Z (born after 1996). We use these named groups, as it is the most widely-used classification of generations in the western world and as a result are widely recognised. Furthermore, (media) reports and several recent academic studies have used this classification to discuss generational differences in relation to climate change[16,28,29].

Results

Generational differences in climate-related beliefs, risk perceptions and emotions. Participants in the surveys responded to ten questions to assess their beliefs, risk perceptions and experienced emotions regarding climate change. Most questions used a 5-point response scale, with higher scores indicating higher levels of belief in the anthropogenic nature, temporal proximity and urgency of climate change, higher levels of perceived risks and

threats, and more strongly felt emotions. The temporal proximity question ("already feeling the effects") was dichotomized due to the distribution of scores (67%, 65% and 68% indicated that they think we are already feeling the effects of climate change in 2020, 2021 and 2022 respectively).

Table 1 shows the mean scores and standard deviations for the ten questions for the five generation groups in 2020, 2021, and 2022 respectively. There is an overall pattern of higher levels of climate-related beliefs, risk perceptions and emotions among the younger generation groups, in particular in 2020. While the differences between the generation groups appear less profound in 2021 and 2022, with Generation Z and Millennials having slightly lower scores and the Boomers I and Post war group having slightly higher scores than in 2020, the overall pattern is the same.

Linear and logistic regression analyses of the responses show that there were no significant differences in the perceived causes and urgency of climate change across the five generation groups in 2020 (see Table 2). The Boomer II group are however more than two-and-a-half times more likely than the Generation Z group to think "we are already feeling the effects" of climate change (OR = 2.70, 95%CI [1.24, 5.84]). While there were no significant differences in the perceived impacts of climate change across the generation groups, the perceived threats to self and family and to the UK were lower for all generation groups as compared to Generation Z. Similarly, the Generation X, Boomer II, and Boomers I and older groups were less worried, and less strongly felt the emotions of fear, guilt and outrage. Overall, these results suggests that, while there are no major differences in climate-related beliefs, there may be a generation gap in climate-related risk perceptions and emotions.

Table 2 further shows there were fewer significant differences between the generations in 2021 and 2022. In contrast to the results from 2020, the Boomers II and Boomers I and older groups show a higher belief in the anthropogenic nature of climate change as compared to Generation Z in 2021. However, this difference is absent again in 2022. The two groups (and Millennials in 2022) also had a higher level of belief that we are already feeling the effects of climate change compared to Generation Z in both years (OR = 2.30, 95%CI [1.15, 4.72] and OR = 4.66, 95%CI [2.40, 9.04] for the Boomers II group in 2021 and 2022, respectively; OR = 4.04, 95%CI [2.00, 8.19] and OR = 3.42, 95%CI [1.76, 6.65] for the Boomers I and older group in 2021 and 2022, respectively; and OR = 2.54, 95%CI [1.35, 4.81] for the Generation X group in 2022). No major differences in climate-related risk perceptions were found between the different generation groups in 2021 or 2022, with only a few significant effects, which is in contrast to the results for 2020. Most significantly, there were still generational differences in the strength of climate-related emotions in both 2021 and 2022, in particular between the two baby boomer groups and Generation Z.

Climate-related beliefs, risk perceptions and emotions as repeated measures. The results from the linear and logistic regression analyses suggest that the generational gap is stronger for climate-related risk perceptions and emotions than for climate-related beliefs, and that this gap diminished between 2020 and 2021/2022. To more robustly test generational differences, we conducted a series of consecutive multilevel regression models in which nine out of the ten variables were considered as repeated measures (Level 1) clustered within individuals (Level 2). This approach allows for cross-level interactions between the different generational groups on the one hand and the type of measures (i.e., whether they are about climate-related beliefs, risk perceptions or emotions) on the other.

Table 1 Means (M) and Standard Deviations (SD) in climate-related beliefs, risk perceptions and emotions for the five named generation groups in 2020, 2021 and 2022.

Year	Generation	n	Beliefs				Risk perceptions								Emotions							
			Perceived causes		Already feeling the effects (1)		Perceived urgency		Perceived impacts		Perceived threat to self and family		Perceived threat to the UK		Worry		Fear		Guilt		Outrage	
			M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
2020	Generation Z	54	3.69	(0.86)	0.67	(0.47)	3.75	(1.10)	3.88	(1.12)	3.48	(1.04)	3.83	(0.89)	3.96	(0.82)	3.22	(1.21)	2.80	(1.17)	3.07	(1.32)
	Millennials	488	3.54	(1.01)	0.67	(0.47)	3.63	(1.01)	3.94	(0.89)	3.09	(1.04)	3.50	(1.01)	3.34	(1.03)	2.72	(1.23)	2.45	(1.10)	2.60	(1.22)
	Generation X	542	3.41	(1.03)	0.69	(0.46)	3.52	(1.09)	3.92	(0.82)	2.94	(1.06)	3.28	(1.05)	3.14	(1.07)	2.48	(1.22)	2.21	(1.09)	2.38	(1.23)
	Boomers II	391	3.60	(0.95)	0.83	(0.38)	3.78	(1.05)	3.95	(0.78)	2.99	(1.08)	3.40	(1.06)	3.29	(1.11)	2.56	(1.28)	2.17	(1.11)	2.55	(1.32)
	Boomers I and older	410	3.40	(0.96)	0.77	(0.42)	3.58	(1.05)	3.81	(0.82)	2.77	(1.09)	3.21	(1.08)	3.15	(1.08)	2.27	(1.25)	1.94	(1.02)	2.29	(1.29)
2021	Generation Z	88	3.54	(1.10)	0.64	(0.48)	3.66	(1.09)	3.87	(0.90)	3.29	(1.03)	3.67	(0.99)	3.60	(1.09)	3.14	(1.22)	2.81	(1.18)	2.95	(1.28)
	Millennials	258	3.39	(1.18)	0.60	(0.49)	3.69	(1.05)	3.70	(1.10)	3.37	(1.04)	3.59	(1.01)	3.57	(1.05)	3.02	(1.25)	2.79	(1.29)	2.98	(1.30)
	Generation X	265	3.33	(1.14)	0.69	(0.46)	3.67	(1.15)	3.81	(1.05)	3.15	(1.22)	3.50	(1.12)	3.38	(1.12)	2.72	(1.27)	2.43	(1.26)	2.64	(1.34)
	Boomers II	172	3.55	(1.08)	0.76	(0.43)	3.65	(1.19)	3.91	(0.93)	2.95	(1.19)	3.37	(1.15)	3.22	(1.12)	2.48	(1.22)	1.88	(1.00)	2.20	(1.22)
	Boomers I and older	207	3.60	(0.94)	0.83	(0.38)	3.84	(1.03)	3.86	(0.94)	3.03	(1.08)	3.42	(1.00)	3.31	(1.08)	2.58	(1.18)	1.99	(1.03)	2.45	(1.25)
2022	Generation Z	103	3.63	(0.96)	0.65	(0.48)	3.77	(0.95)	3.92	(1.00)	3.16	(1.04)	3.61	(0.91)	3.69	(0.93)	3.17	(1.26)	2.69	(1.26)	3.15	(1.29)
	Millennials	300	3.38	(1.14)	0.64	(0.48)	3.61	(1.02)	3.73	(1.14)	3.33	(1.03)	3.62	(1.01)	3.60	(1.03)	2.96	(1.25)	2.63	(1.22)	2.74	(1.31)
	Generation X	240	3.51	(0.99)	0.78	(0.42)	3.55	(1.12)	4.07	(0.85)	3.07	(1.10)	3.35	(1.06)	3.36	(1.12)	2.64	(1.29)	2.23	(1.16)	2.43	(1.28)
	Boomers II	247	3.56	(0.97)	0.83	(0.37)	3.67	(1.03)	4.01	(0.72)	2.94	(1.04)	3.26	(1.05)	3.36	(1.06)	2.66	(1.22)	2.00	(1.02)	2.43	(1.26)
	Boomers I and older	191	3.56	(0.93)	0.77	(0.42)	3.64	(1.02)	3.83	(0.91)	2.97	(1.07)	3.31	(1.01)	3.33	(1.14)	2.47	(1.22)	1.90	(0.99)	2.27	(1.21)

¹The mean (M) represents the proportion who indicated that they thought "We are already feeling the effects" of climate change.

Table 2 Linear and logistic regression models predicting climate-related beliefs, risk perceptions and emotions in 2020, 2021 and 2022 (unstandardised regression coefficients (B) and 95% confidence intervals (CI)).

Year	Generation(3)	Beliefs			Risk perceptions			Emotions			
		Perceived causes(1)	Already feeling the effects(2)	Perceived urgency(1)	Perceived impacts(1)	Perceived threat to self and family(1)	Perceived threat to the UK(1)	Worry(1)	Fear(1)	Guilt(1)	Outrage(1)
2020	Millennials	−0.139 (−0.458, 0.18)	−0.198 (−0.952, 0.557)	−0.142 (−0.477, 0.194)	0.114 (−0.159, 0.387)	−0.476*** (−0.792, −0.160)	−0.498*** (−0.836, −0.160)	−0.640*** (−0.981, −0.300)	−0.252 (−0.653, 0.150)	−0.171 (−0.520, 0.178)	−0.357 (−0.767, 0.053)
	Generation X	−0.189 (−0.505, 0.127)	0.181 (−0.565, 0.928)	−0.127 (−0.458, 0.204)	0.214 (−0.054, 0.483)	−0.569*** (−0.917, −0.221)	−0.667*** (−1.001, −0.334)	−0.746*** (−1.082, −0.410)	−0.472** (−0.869, −0.076)	−0.366** (−0.710, −0.021)	−0.484** (−0.889, −0.079)
	Boomers II	−0.012 (−0.331, 0.308)	0.992*** (0.219, 1.765)	0.120 (−0.215, 0.456)	0.245 (−0.027, 0.517)	−0.543*** (−0.895, −0.191)	−0.565*** (−0.903, −0.227)	−0.615*** (−0.954, −0.275)	−0.438** (−0.840, −0.037)	−0.436** (−0.785, −0.088)	−0.415** (−0.825, −0.005)
	Boomers I and older	−0.152 (−0.471, 0.167)	0.708 (−0.052, 1.467)	0.009 (−0.325, 0.343)	0.174 (−0.097, 0.446)	−0.668*** (−1.020, −0.317)	−0.687*** (−1.024, −0.351)	−0.675*** (−1.014, −0.336)	−0.633*** (−1.033, −0.233)	−0.594*** (−0.942, −0.246)	−0.573** (−0.982, −0.164)
2021	Millennials	0.182 (−0.127, 0.491)	0.143 (−0.519, 0.805)	0.248 (−0.078, 0.573)	0.068 (−0.223, 0.360)	0.219 (−0.113, 0.552)	−0.040 (−0.353, 0.274)	0.160 (−0.157, 0.477)	−0.033 (−0.393, 0.328)	0.107 (−0.237, 0.450)	0.004 (−0.380, 0.387)
	Generation X	0.108 (−0.195, 0.411)	0.553 (−0.100, 1.206)	0.249 (−0.070, 0.568)	0.149 (−0.138, 0.435)	−0.046 (−0.373, 0.281)	−0.117 (−0.425, 0.192)	−0.030 (−0.341, 0.281)	−0.315 (−0.670, 0.039)	−0.281 (−0.618, 0.057)	−0.333 (−0.709, 0.044)
	Boomers II	0.370** (0.048, 0.692)	0.845*** (0.138, 1.552)	0.222 (−0.116, 0.561)	0.320** (0.016, 0.624)	−0.206 (−0.555, 0.142)	−0.242 (−0.569, 0.086)	−0.176 (−0.507, 0.154)	−0.594*** (−0.971, −0.218)	−0.825*** (−1.184, −0.466)	−0.820*** (−1.220, −0.420)
	Boomers I and older	0.407** (0.097, 0.717)	1.397*** (0.692, 2.103)	0.459*** (0.131, 0.786)	0.221 (−0.072, 0.515)	−0.124 (−0.459, 0.211)	−0.204 (−0.520, 0.112)	−0.069 (−0.388, 0.249)	−0.442** (−0.806, −0.078)	−0.735*** (−1.081, −0.389)	−0.539** (−0.925, −0.153)
2021	Millennials	−0.198 (−0.466, 0.071)	0.240 (−0.364, 0.844)	−0.086 (−0.365, 0.193)	−0.090 (−0.334, 0.154)	0.085 (−0.203, 0.373)	0.017 (−0.259, 0.292)	−0.024 (−0.314, 0.265)	−0.080 (−0.412, 0.252)	0.007 (−0.287, 0.300)	−0.301 (−0.643, 0.041)
	Generation X	−0.076 (−0.349, 0.197)	0.934*** (0.297, 1.571)	−0.112 (−0.396, 0.173)	0.346** (0.097, 0.595)	−0.156 (−0.451, 0.138)	−0.237 (−0.519, 0.045)	−0.245 (−0.541, 0.050)	−0.414** (−0.753, −0.075)	−0.392** (−0.691, −0.092)	−0.663** (−1.012, −0.314)
	Boomers II	0.017 (−0.255, 0.289)	1.539*** (0.877, 2.202)	0.096 (−0.188, 0.379)	0.323** (0.075, 0.570)	−0.272 (−0.565, 0.022)	−0.319** (−0.599, −0.039)	−0.209 (−0.503, 0.086)	−0.313 (−0.650, 0.025)	−0.528** (−0.827, −0.229)	−0.574** (−0.922, −0.226)
	Boomers I and older	0.096 (−0.185, 0.377)	1.231*** (0.568, 1.894)	0.092 (−0.200, 0.384)	0.173 (−0.082, 0.427)	−0.219 (−0.522, 0.083)	−0.246 (−0.535, 0.043)	−0.223 (−0.527, 0.081)	−0.505** (−0.854, −0.156)	−0.674** (−0.983, −0.365)	−0.707** (−1.066, −0.347)

[1]Linear regression, [2]Logistic regression, [3]Reference group is Generation Z. **$p < 0.05$; ***$p < 0.01$; The analyses were controlled for the socio-demographics of gender, education, political orientation, and home nation.

An empty 'null' model, without any predictors, shows that the intraclass correlation (ICC) was 0.39 in 2020. The ICC expresses the fraction of the total variation that can be accounted for by between-person differences rather than within-person differences. This means that 39% of the variance is shared across the nine repeated measures. This shared variance can be attributed to the individual and is likely to reflect a person's general concern about climate change. Comparable results were found for 2021 (ICC = 0.36) and 2022 (ICC = 0.33).

Results in Table 3 show that, in 2020, the two baby boomer groups expressed less engagement with climate change across the nine repeated measures (Model 1). When the different types of measures were considered in Model 2, it appeared that the generational differences were in climate-related risk perceptions and emotions, and not in climate-related beliefs. In particular, the Boomers II and Boomers I and older groups had lower climate-related risk perceptions and emotions than Generation Z, while Generation X only had lower climate-related emotions than Generation Z.

The results suggest that the generational gap in engagement with climate change across the nine repeated measures did not exist in 2021 and was smaller in 2022 than in 2020 (Model 1). When differences in the three types of measures were considered in Model 2, results for 2021 were largely comparable to those for 2020, in that there are similar generational differences in climate-related risk perceptions and emotions. The study however suggests that the change is only for climate-related beliefs, and not for perceived risks or emotions. Results from 2022 largely followed the same pattern, although generational differences for risk perceptions also disappeared in this period. The differences in emotional engagement with climate change however remained significant across all years. This adds confidence to the finding that differences between generation groups are mainly regarding affective, not cognitive, engagement with climate change.

When combining the three survey years for an overall analysis (see Supplementary Table 1), it appears that Generation X and the two baby boomer groups have less engagement with climate change than Generation Z, and that these differences are due to differences in risk perceptions and climate-related emotions. The two baby boomer groups have lower climate related risk perceptions and emotions than Generation Z, while Generation X only has lower climate related emotions. Overall, there were no differences in climate engagement between Millennials and Generation Z.

Discussion

Using three nationally-representative surveys conducted in 2020 to 2022 in the UK, we conclude that generational differences are mainly found in emotional engagement with climate change and less so with regards to cognitive beliefs about the reality and causes of climate change. More precisely, our results show that younger generations more strongly feel the negative emotions of fear, guilt and outrage as compared to older generations. Generational differences in climate change beliefs and perceived impacts were smaller and appear to have narrowed from 2020 to 2021/2022. A surprising finding is that older generations are more likely to think that we are already feeling the effects of climate change. The findings for risk perceptions were more variable across the three surveys, but in two out of the three years we replicate previous research showing that younger people have higher levels of risk perception as well as worry about climate change than older generations[15]. Overall, the findings show the importance of clearly distinguishing between the different constructs of climate-related beliefs, risk perceptions and emotions and consider them separately when exploring generational patterns.

Table 3 Multilevel regression models predicting climate-related beliefs, risk perceptions and emotions in 2020, 2021 and 2022 (unstandardised regression coefficients (B) and 95% confidence intervals (CI)).

	2020		2021		2022	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Millennials	−0.301** (−0.553, −0.048)	−0.164 (−0.472, 0.144)	0.092 (−0.139, 0.322)	0.123 (−0.163, 0.408)	−0.081 (−0.281, 0.120)	−0.193 (−0.447, 0.060)
Generation X	−0.380*** (−0.629, −0.132)	−0.179 (−0.483, 0.125)	−0.081 (−0.308, 0.145)	0.117 (−0.164, 0.398)	−0.231** (−0.436, −0.027)	−0.123 (−0.381, 0.134)
Boomers II	−0.303** (−0.555, −0.051)	0.035 (−0.273, 0.343)	−0.231 (−0.472, 0.009)	0.229 (−0.069, 0.526)	−0.201 (−0.405, 0.003)	0.020 (−0.236, 0.276)
Boomers I and older	−0.421*** (−0.672, −0.169)	0.083 (−0.390, 0.224)	−0.120 (−0.352, 0.112)	0.354** (0.067, 0.642)	−0.245** (−0.456, −0.035)	0.038 (−0.226, 0.302)
Risk perceptions (versus Beliefs)		0.084 (−0.164, 0.332)		0.114 (−0.107, 0.334)		−0.101 (−0.300, 0.098)
Emotions (versus Beliefs)		−0.540*** (−0.774, −0.306)		−0.344*** (−0.550, −0.137)		−0.572*** (−0.761, −0.383)
Millennials x Risk perceptions		−0.160 (−0.422, 0.103)		−0.063 (−0.312, 0.187)		0.177 (−0.051, 0.405)
Generation X x Risk perceptions		−0.180 (−0.439, 0.079)		−0.150 (−0.397, 0.097)		0.085 (−0.146, 0.317)
Boomers II x Risk perceptions		−0.346*** (−0.608, −0.084)		−0.302** (−0.563, −0.041)		−0.115 (−0.344, 0.115)
Boomers I and older x Risk perceptions		−0.330** (−0.591, −0.069)		−0.403*** (−0.655, −0.151)		−0.141 (−0.376, 0.094)
Millennials x Emotions		−0.186 (−0.434, 0.061)		−0.027 (−0.262, 0.207)		0.124 (−0.091, 0.340)
Generation X x Emotions		−0.325*** (−0.569, −0.081)		−0.335*** (−0.566, −0.103)		−0.297*** (−0.516, −0.077)
Boomers II x Emotions		−0.501*** (−0.749, −0.254)		−0.802*** (−1.047, −0.557)		−0.409*** (−0.626, −0.192)
Boomers I and older x Emotions		−0.523*** (−0.770, −0.277)		−0.769*** (−1.006, −0.533)		−0.531*** (−0.754, −0.309)

**p < 0.05, ***p < 0.01. The analyses were controlled for the socio-demographics of gender, education, political orientation, and home nation.

The results provide further clarity to the literature showing that age is of little relevance for climate change scepticism[30], but that it is an important factor in threat perceptions, climate change worry and other climate-related emotions[1,3,16]. This suggests that, while there are only negligible differences in climate-related cognitions, younger age groups show stronger emotional engagement with climate change. Although the current study did not explicitly focus on climate anxiety, one of the clearest differences identified was for the emotion of fear. Fear can be a corrosive emotion and could take a heavy toll on younger generations by affecting their action and wellbeing negatively[4], although experienced negative emotions may also have more positive, motivational effects[7]. Emotions have been shown to play an important role in human responses to climate change[31], and can help evoke adaptive coping reactions, including sustainable behaviour[7], support for climate policies[32], social support[16], and climate activism[33]. The greater intensity of emotions, such as outrage, may be one of the reasons as to why younger generations demonstrate high levels of active engagement with the issue of climate change[34]. It is worth noting that the emotions of fear, guilt and outrage are generally experienced less than worry, and that all average scores are below the scale midpoint except some for Millennials (i.e. fear) and Generation Z (i.e. fear and outrage), which are just above the scale midpoint. This suggests that climate-related emotions have not yet reached levels that could lead to maladaptive responses or interfere with the younger generation's ability to function at this stage[4,5].

Our study further identified some notable differences in generational effects between our samples over the last three years. While similar generational differences were found in regard of climate-related emotion, the overall generational gap appears to have diminished from 2020 to 2021/2022 due to a narrowing of climate-related beliefs and to some extent climate-related risk perceptions. This is in contrast to the received understanding and previous research showing that older age groups have lower agreement with anthropogenic climate change[35]. Older generations even appear to have higher levels of beliefs regarding the temporal proximity of climate change than younger generations. This effect may be explained by the declining remarkability of temperature anomalies. Temperature anomalies are rapidly becoming the new normal and are notably different to people who have experienced previous lower frequencies of extreme weather events[36]. This leads to shifting baselines to which current temperatures and experiences with climate-related events are compared[37]. That is, older age groups are able to compare current temperatures and events with a longer reference period when they were less affected by anthropogenic climate change.

The observed generational gap diminishing from 2020 to 2021/2022 may be due to increased media reporting and attention to the topic[38]. Mass protests by the Fridays for Future and Extinction Rebellion movements, the publication of the IPCC special report on 1.5 °C global warming, and extreme weather events had already pushed climate change higher up the media and public agendas[8,39,40], only for attention for the issue to be overwhelmed by the COVID-19 pandemic in 2020[41]. The following year saw a resurgence in media coverage of climate change in the UK, in particular following the publication of the UK Net Zero Strategy and reaching a peak at the time of the COP26 conference in Glasgow[38].

The contribution of the current research is that it examined generational differences across different types of climate engagement including cognitive and affective dimensions. While previous studies have examined generational differences for specific construct measures, and age is routinely included as a socio-demographic factor in climate perception research, this is the first-time generational differences were examined jointly for

climate-related beliefs, risk perceptions and emotions. However, the study is cross-sectional, and it is therefore not possible to determine whether the generational differences in climate-related beliefs, risk perception and emotions are due to developmental or cohort effects[35]. The generational differences may be the result of differences in experiences and conditions the different age groups may have had at key stages of their life or reflect that people's views develop and change as they grow older.

One of the main findings of the study is that generation gap is most consistent when it comes to affective responses to climate change. The question here is whether younger generations will develop less affective response to climate change as they age in line with the current older generation, or whether the experienced emotions will continue or even strengthen. The increasing frequency and severity of extreme weather events[42], and the psychological responses they evoke[43,44], suggest that climate anxiety among younger age groups is unlikely to follow the same trajectory as older age groups. Cohort and developmental effects can however only be disentangled with well-designed longitudinal studies, which are currently not available. In addition, it is possible that there are period or era effects where all age groups experience the same events and conditions, but the impacts may differ for each group[16,45,46]. There are indications that cohort, developmental and period effects all play a role in the patterns of engagement with climate change across the different age groups. People become more politically conservative as they age[47] and develop value and trait patterns that are less conducive to an environmental worldview[48–51]. The results from this study suggest that events that have taken place in the past few years (such as increased media attention, Fridays for Future and Extinction Rebellion protests, and COP26) have had differential impacts across the different generational groups considered, indicating period effects. Other longitudinal research, using 10-year panel data from New Zealand, shows that that older age cohorts started from a lower level of climate change belief, but that different age cohorts increased their belief level at a similar rate[35]. Milfont et al. (2021) were however only able to conduct the analyses for climate change beliefs. Currently, there are no good quality datasets available that allow similar analyses across the different dimensions of climate engagement that were considered in the current study.

In this paper we used the named generations to explore generational differences in engagement with climate change named generational groups based on the theory of generations. It has to be considered that the different generational groups vary in their time span. The baby boomer generation covers almost two decades (and was therefore divided into two sub-groups), Generation X and Millennials span about 15 years each, and Generation Z only involved up to eight years in this study. The relatively large time span of some of the generational groups may mean that individuals who are born close to the cut off with other generation groups may have more in common with those other groups than individuals who are born in the middle of the cohort. Furthermore, given that not all of Generation Z had turned 18 yet at the time of our surveys, this generational group was relatively small and as a result only had small samples in the three survey years. This may have affected the statistical power to detect differences with other generational groups, such as Millennials. We therefore conducted an additional analysis using similarly sized age cohorts of 10 years (born in 2004–1993, 1992–1983, 1982–1973, 1972–1963, 1962–1953, and 1952- and before). These age cohorts broadly match the Generation Z, Millennials, younger Generation X, older Generation X, Boomers II and Boomers I, respectively. The descriptive results for the different age cohorts are provided in Table Supplementary Table 2. The results of the multilevel analysis are provided in Supplementary Table 3. The

age cohort analysis validates the results from the generational analysis. There are only minimal differences between the 2004–1993 and 1992–1983 cohorts (roughly matching Generation Z and Millennials, respectively). Generational differences can be found between the 2004–1993 cohort on the one hand and the 1982–1973, 1972–1963, 1962–1953, and 1952 – cohorts on the other. The 1972–1963, 1962–1953, and 1952 – cohorts (roughly matching older Generation X, Boomers II and Boomers I, respectively) have lower climate-related risk perceptions and emotions than the 2004–1993 cohort, while the 1982–1973 cohort (younger Generation Xers) only has lower climate related emotions as compared to the 2004–1993 cohort. This shows that even with other cut-off points for the age groups, the main conclusion still holds that the generation gap is most consistent when it comes to affective responses to climate change, rather than to beliefs about whether climate change exists or is caused by human activity.

Remaining research gaps are about whether similar patterns can be found in other countries and cultures. The named generations used in this study are based on the theory of generations that was developed in a Western context and anchored around events and conditions within the Western world. Similar generational groups and patterns may therefore not apply to different countries or populations. Furthermore, little is known about the consequences of generational differences in engagement with climate change. The implications of climate related emotions for younger generations' mental and physical wellbeing need to be considered[4], including how cognitive and emotional engagement can be fostered for constructive and avoiding maladaptive outcomes[6]. Here it is essential to not put the onus on the younger generations to take action. Older generations are in a position of power to shape policies that will help to reduce the risks for future generations. The current study shows that, while there are no generational differences in the acknowledgement of the reality and seriousness of climate change, emotional engagement among older generations appears to be lacking. An important avenue of research is therefore on how communications and interventions can be used to bolster the emotional engagement of older generations for the benefit of the younger and future generations.

Methods

The surveys. We used the first three waves of a series of cross-sectional online surveys conducted by the CAST Centre, with data collected between 29th September and 26th October 2020, 28th August and 22nd September 2021, and 5th September and 6th October 2022 by the survey company DJS research. Participants were recruited through online panels. Informed consent was obtained from all participants. The samples were broadly representative of the British population with quotas for gender, age, region, and socioeconomic status. The methodology used to collect the data was consistent across the three waves of the survey. The first wave (2020) of data consisted of 1893 participants, including booster samples in Scotland ($n = 485$) and Wales ($n = 467$). The second wave (2021) of data consisted of 1001 participants. The third wave (2022) included 1087 participants. The surveys obtained approval from the School of Psychology Research Ethics Committee (Wave 1: EC.20.08.11.6068; Wave 2: EC.21.08.10.6385; Wave 3: EC.22.07.12.6597).

Measures. The CAST surveys cover a wide range of topics relating to climate change perceptions, policy support and willingness to change behaviours in the areas of food and diet, transport and mobility, household energy use, and material consumption. Here, we specifically focus on the items that were designed to measure climate-related beliefs, risk perceptions and emotions respectively (see Table 1).

Climate-related beliefs comprised three items. Perceived causes of climate change was measured with the item "Thinking about the causes of climate change, which, if any, of the following best describes your opinion". Participants answered the question using a scale that ranged from 1 (Climate change is entirely caused by natural processes) to 5 (Climate change is completely caused by human activity), with 3 representing "Climate change is partly caused by natural processes and partly caused by human activity". A few responded with "There is no such thing as climate change" ($n = 18$, $n = 23$, and $n = 7$ for the three waves respectively), which was coded as 0. Perceived temporal distance was measured with the item "When, if at all, do you think the UK will start feeling the effects of climate change?". Here,

respondents could choose from seven options (We are already feeling the effects; In the next 10 years; In the next 25 years; In the next 50 years; In the next 100 years; Beyond the next 100 years; Never). The distribution of responses warranted a recoding into a dummy variable to compare "We are already feeling the effects" (1) against all other responses (0). 66.8%, 64.6% and 68.4 of the respondents said that we are already feeling the effects of climate change in 2020, 2021, and 2022 respectively, with low numbers for the remaining categories (9.6%, 7.0%, 3.8%, 1.0%, 1.2% and 2.0% for 2020; 11.6%, 8.3%, 3.6%, 0.7%, 1.2% and 1.9% for 2021; and 11.2%, 6.5%, 3.1%, 1.4%, 0.9% and 0.9% for 2022). Respondents indicated their perceived level of urgency in response to the question "Which of these best describes your views about the level of urgency with which climate change needs to be addressed?". The response scale ranged from 1 (Addressing climate change requires little or no urgency) to 5 (Addressing climate change requires and extremely high level of urgency).

Climate-related risk perceptions consisted of the perceived impacts of climate change ("Overall, how positive or negative do you think the effects of climate change will be on the UK?"), and the perceived threats of climate change to (a) self and family, and (b) to the UK ("How serious a threat, if at all, is climate change to each of the following?"; (a) "… you and your family", and (b) "…the UK as a whole"). The former could be answered using a bipolar 5-point answer scale anchored by 1 (Entirely positive) and 5 (Entirely negative), and a scale midpoint of 3 (Neither positive nor negative). The latter could be answered using a unipolar 5-point answer scale ranging from 1 (Not serious at all) to 5 (Extremely serious).

Climate-related emotions comprised "worry", "fear", "guilt" and "outrage". Respondents expressed their levels of worry about climate change on a 5-point scale, ranging from 1 (Not at all worried) to 5 (Extremely worried). Respondents were asked to indicate their levels of fear, guilt and outrage in response to the question "When you think about climate change and everything that you associate with it, how strongly, if at all, do you feel each of the following emotions?". Here respondent could use a scale ranging from 1 (Not at all) to 5 (Very much).

The main independent variable comprised the categorisation of respondents into the seven main generations of *Generation Z* (born between 1996–2010), *Millennials* (born between 1981 and 1995), *Generation X* (born between 1965 and 1980), *Boomers II* or *Generation Jones* (born between 1955 and 1964), *Boomers I* (born between 1946 and 1954) and the *Post-war* or *'silent' generation* (born between 1928 and 1945). The survey did not include respondents from the *Greatest generation* (born between 1901 and 1927). Due to the low numbers for the Post-war generation, these were combined with the Boomers I groups. The study further used the covariates of *gender* (male and female), *education* (having a university degree or not) *political orientation*, and *home nation* (England, Scotland or Wales). Political orientation was determined using an 11-point self-placement scale ranging from 1 (left) to 11 (right). The scale was standardised by calculating the Z scores across the three waves (Wave 1: $M = 6.29$, SD = 2.57; Wave 2: $M = 6.40$, SD = 2.22; $M = 6.18$, SD = 2.21).

Analytical approach. The cross-sectional analyses consisted of a series of (1) linear and logistic regressions and (2) multilevel analyses. All analyses were conducted using R statistical software (version 4.0.2) in combination with RStudio (version 2021.09.0 + 351) and the stats[52] and lme4[53] packages. The R code can be accessed at https://doi.org/10.17605/OSF.IO/DKRCB.

First, the different climate-related beliefs (perceived causes, already feeling effects, and perceived urgency of climate change), risk perceptions (perceived impacts, perceived threat to self and family, and perceived threat to the UK), and emotions (worry, fear, guilt and outrage) were regressed on the different generational groups, with Generation Z as the reference group. Gender, degree, and political orientation were included as covariates. Linear regression models were constructed, except for 'already feeling the effects' for which an ordinal regression model was fitted. Analyses were conducted separately for the three consecutive survey years.

Second, the data were analysed from a multilevel repeated measures perspective[54]. This specific cross-sectional analysis considers the climate-related beliefs, risk perceptions and emotions as repeated measures (Level 1) that are nested within participants (Level 2). In this approach the measures can be conceptualised as repeated judgments about climate change made by (and thus nested within) individuals, with the judgments differing in terms of their content, i.e. they are judgments relating to the reality and nature of climate change (beliefs), the risks and consequences of climate change (risk perceptions), and how climate change is experienced emotionally (emotions) respectively. This approach can be used to apportion variance that is specific to and common across the different measures, and thus allows for the assessment of cross-level interactions between measure-specific (e.g. measure type) and individual-level characteristics (e.g. generational group). Two sets of multilevel models were constructed. The first set (Model 1) included the different generation groups, the covariates as the independent variables (gender, education, and political orientation). The second set (Model 2) added two measure-specific dummy variables identifying the Risk perception and Emotion questions respectively, as well as their interactions with the different generation groups. Generation Z was used as the reference group throughout. In both models, the different climate-related beliefs, risk perceptions and emotions served as the dependent variables. The binary 'already feeling the effects' variable was omitted from the analyses. An empty 'null' model (Model 0), without any predictors, was also constructed to estimate the intraclass correlation (ICC), representing the proportion of variance that is common across the different measures and thus can be attributed to the individual (Level 2) rather than to a specific measure (Level 1). The analyses were conducted separately for 2020, 2021, and 2022 data, with a combined analysis provided in Supplementary Table 1.

Data availability

All data and accompanying documents can be accessed at https://doi.org/10.17605/OSF.IO/DKRCB. All data and accompanying documents can be accessed at the UK Data Service (https://ukdataservice.ac.uk) after 31 July 2024.

Code availability

The questionnaires and R code can be accessed at https://doi.org/10.17605/OSF.IO/DKRCB.

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Author contributions

W.P.: conceptualization, formal analysis, methodology, writing – original draft, review and editing. C.D.: writing – original draft, and review and editing. K.S.: writing – original draft, and review and editing. All authors contributed to the design of the CAST surveys. All authors contributed to the article and approved the submitted version.

Competing interests

The authors declare no competing interests.

Additional information

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