

Opinions of 12 to 13-year-olds in Austria and Australia on the worry, cause and imminence of Climate Change

Authors: Inez Harker-Schuch, Frank Mills, Steven Lade, Rebecca Colvin

The Australian National University (ANU)

Abstract

Although we are in the third decade of climate science communication as a discipline, and there is overwhelming scientific consensus and physical evidence for climate change, the general public continues to wrestle with climate change policy and advocacy. Early adolescence (12 to 13 years old) is a critical but under-researched demographic for the formation of attitudes related to climate change. This paper presents opinions on the worry, cause, and imminence of climate change that were collected from $n=463$ 1st year secondary school students (12-13 years old) in public secondary schools in inner-urban centres in Austria and Australia. Overall, 86.83% of eligible respondents agreed that climate change was probably or definitely something we should worry about, 80.33% agreed that climate change was probably or definitely caused by humans, and 83.17% agreed that climate change was probably or definitely something that was happening now. The respondents' opinions were also compared to their respective adult population, with Australian 12-13 year olds showing strong positive climate-friendly attitudes, both in comparison to their adult population, and to their Austrian peers. In addition, although the opinions of Austrian 12-13 year olds were quite high, they did not reflect the higher climate-friendly opinions of their adult community. Our results suggest that socio-cultural worldview or socio-cultural cognition theory may not have the influence on this age group as it does on the respective adult population – and, if they are affected, there are attitudes or factors in this age group which resist the opinion-influence from their mature community. These findings are significant as early adolescents may be pivotal in the climate science communication arena and investigating their opinions with regard to climate change may offer an unexplored and under-utilised target for future communication efforts and climate literacy programmes.

Introduction

Despite more than 30 years at the forefront of the political and social agenda, meaningful climate change governance continues to be thwarted by disconnects between scientific knowledge, public knowledge and trust of climate science. A great number of studies have been undertaken (international and regional) ¹⁻⁵ to provide context for this disconnect and to measure adult public opinions over time – with only marginal improvement in public opinion. This paper challenges the focus on adults and proffers an alternative focus on a significantly under-researched group: the early adolescent ⁶. With the abundance of data related to adult opinions about climate change, this paper examines the same (or similar) climate change opinions of 12-13-year-olds. We compare their opinions with their respective adult population, and also across two countries (Austria and Australia). This age group may provide a unique and unexplored avenue for climate science communication (Harker-Schuch, 2018); offering as-yet uncharted access to early worldview-construction development and, more critically, intellectual development pathways. In addition to improving understanding of climate science, such avenues may also improve support for climate-friendly policy and advocacy.

The challenges of communicating climate change

Aligning public opinions with the scientific consensus on the influence of human-induced climate change is an ongoing challenge for both science communicators and those who recognise the essential role the general public play in mitigating and adapting to anthropocentric climate change ⁸⁻¹⁰. This challenge arises, in relation to science communication, on account of 1) individual socio-cultural/-political worldviews ¹¹, 2) misinformation ^{10,12,13}, 3) the cultivation of unwelcome emotions (anxiety, doubt, mistrust, confusion, overwhelming) ¹⁴⁻¹⁶ 4) the complexity and nature of the science ^{17,18}, 5), a lack of common or shared

46 knowledge, 6) the wicked nature of climate change and, lastly, 7) a lack of certainty^{19,20} with regard to the
47 scientific consensus or trust in the findings from the scientific community.

48 Navigating 1) worldview is, perhaps, the most pernicious challenge to overcome as it involves the
49 individual's idiosyncratic belief system and their attachment to social, political and cultural networks^{11,21}.
50 Worldview is a factor known to not only prevent, but to inoculate an individual from re-assessing existing
51 opinions or idiosyncratic belief systems^{22,23}. Attempts to promote re-assessment of beliefs can lead to an
52 individual entrenching their opinion more firmly and undermining further communication efforts².

53 In addition to worldview, a great deal of 2) misinformation is generated both when lay-people attempt to
54 rationalise and organise the information they are given or search for²⁴, as well as misinformation that is
55 created by groups or industries that are threatened by a well-informed general public^{10,25–27}

56 With regard to 3) emotions, the issue of climate change has been found to engender fear^{28–30}, mistrust and
57 doubt³¹ (both with the scientific community and the broader body politic), as well as confusion about what
58 to do and how to engage with climate change from a human behaviour perspective^{10,32}. Climate change is
59 seen as an overwhelming problem and the mitigation/adaptation options available to individuals do not
60 appear to offer adequate amelioration options – turning off the lights when you leave a room does not seem
61 to be a meaningful response to the global threat of increasing atmospheric temperatures or rising sea levels
62^{33–35}. These emotional responses further paralyse effective engagement³⁶, polarise the issues associated
63 with climate change and reinforce any existing worldview biases. The inability to effectively engage with
64 climate change, coupled with unwelcome emotional responses, may also encourage individuals to ignore or
65 down-play messages or information from science communicators as a means to limit further unwelcome
66 emotions³⁷. As a species, we have never encountered a problem quite like the issue of climate change and
67 we, therefore, lack the skills and perspectives required to analytically and methodically address it.

68 The 4) complexity of the science represents another barrier to science communication^{17,18} as climate change
69 involves many scientific disciplines (chemistry, physics, biology, geology) and is best understood with the
70 expertise of highly specialised climate science fields within those scientific disciplines (e.g. chemistry: trace
71 gases in Earth's atmosphere, physics: astrophysics, biology: coral-mass accretion rates, geology:
72 paleoclimatology and sediment accretion; to name but a very few)^{17,30,38}. Understanding the science is
73 further hindered by the spatial and temporal scale of climate change which operates on spatial scales from
74 the stellar to the molecular (which is unheard of in any other scientific discipline) as well as across time
75 scales ranging from millennia to the momentary^{39,40}.

76 Because climate change wasn't widely understood in the public arena until the mid-1980s⁴¹, climate science
77 was introduced to the curriculum quite recently and is, for most adults, a new science discipline. Very few
78 concepts or ideas related to climate science were taught in school during their childhood and youth, creating
79 a vacuum of 5) common, shared, or familiar knowledge. In addition, climate change is not taught well in
80 most classrooms in the developed world^{12,42–44} and/or is not necessarily offered as a part of the curriculum
81⁴⁵. To complicate matters further, climate change is considered a 6) 'post-normal science' or 'wicked
82 problem' that is defined by criteria that make an effective solution (or compromise) difficult or impossible
83⁴⁶. Climate change is a wicked problem because it has no stopping rule, is both good and bad, is unique and
84 unknown, could be seen as a symptom (as well as a cause), can have findings misinterpreted, has no – as
85 such – definitive formulation, has innumerable solutions which cannot be immediately or ultimately tested,
86 and failed solutions cannot be retracted and will not (and cannot) be tolerated^{47–49}. Lastly, although the
87 'knowledge deficit' model (being sufficiently informed on an issue i.e. climate science, in order to make an
88 informed decision) has been largely dismissed⁵⁰ in view of worldview influences, the importance of climate
89 literacy still forms a fundamental framework for opinion and engagement^{38,51,52}.

90 Finally, the lack of 7) confidence in the scientific community by members of the general public⁵³ (largely
91 driven by targeted campaigns to promote mistrust or to misrepresent climate change as a 'debate')⁵⁴ has

92 impeded climate science communication attempts – and severely retarded efforts to mitigate and adapt to
93 climate change (particularly in the political arena). The single biggest influence on this impediment has
94 been the notion of a ‘debate’ regarding climate science ^{55,56}. Coupled with well-funded denialist campaigns,
95 journalistic integrity to cover ‘both sides’ of an argument (or issue) have seriously interfered with
96 establishing a well-informed public on the issue of climate change ^{4,13}. Like the ‘flat-Earth’ concept, there is
97 no viable counter- or alternative-argument to the theories that report the greenhouse effect phenomena –
98 rendering the “false balance” reporting rationale of ‘both sides’ untenable ⁵⁷.

99 The general scientific literacy of the public is variable, with even fundamental scientific principles poorly
100 understood (e.g. the nature of the Earth’s orbit around the sun) ⁵⁸, let alone the very specific scientific
101 domains (as mentioned above: trace gas atmospheric chemistry - and so on) that form the scientific basis of
102 climate change – leaving many lay-people unaware of the extraordinarily robust body of data (correlations,
103 models and projections) and overwhelming evidence (proxy to empirical) of a human-induced climatic
104 change. Nor is there a strong understanding in the public domain of the scientific consensus in relation to
105 this issue– with 97% of climate scientists providing evidence of anthropogenic climate change ^{59–61}. A
106 recent study by the Pew Research Center in the USA (Politics of Climate Change, 2016), for example,
107 indicated that although 50% of Liberal Democrats believed there was a scientific consensus on climate
108 change, only 16% of conservative Republicans were of the same opinion – representing the strong gap
109 between the public perceptions of, and the real, scientific consensus.

110 With these challenges in mind, and the continuing difficulties the general public have with regard to climate
111 change policy and advocacy, we propose a new target for climate change interventions; one that may
112 possess a stronger alignment with the scientific consensus and, as an extension of this alignment, be more
113 receptive to interventions that promote climate-friendly behaviour and engagement – early adolescents.

114 Why early adolescents matter

115 The early adolescent age group is important – they are the largest group of climate-vulnerable people on
116 Earth and the group with the biggest portion of responsibility ^{6,63} – and they possess three vital
117 characteristics that play a major role in an individual’s ability to comprehend the foundations of the climate
118 change issue ^{7,64–66}. The first is that their brains are undergoing a new intellectual development phase ^{64,66},
119 the second is that their worldview has only just begun to form ^{67,68} and the third is a budding self-
120 determination ^{64–66,69} that will, eventually, drive both their socio-political identity as well as help them
121 secure social capital and community. These three characteristics, known as the 2nd critical phase of
122 development, arise as a result of physiological changes in the human brain that begin shortly before the age
123 of 12 to ensure that healthy individuals will develop the skills they need to enter and manage adult life ⁶⁴.

124 The intellectual development that takes place in this age group allows students to begin to process higher-
125 order executive functions ⁶⁶ and abstract reasoning processes. The mechanisms and processes that underlie
126 climate change – particularly its ‘wickedness’ – require an individual to intellectually perceive the scale and
127 connectedness of those processes and mechanisms. These perceptions are usually only possible once the
128 brain begins this developmental phase ^{64–66}.

129 As well as triggering executive function processing, the brain begins to form socio-political/-cultural
130 worldviews ^{67,68}. In conjunction with the abstract reasoning process, a proto-self-determination arises which
131 is necessary for worldview development – making this age group an ideal ‘starting point’ for informed
132 worldview development ^{70,71}. The construction of these worldviews is strongly influenced by familiar others
133 and by collective actions, attitudes or behaviours that are seen as desirable and help to secure an individual
134 to their peers and respected others ⁶⁶. There is a very short window of opportunity in this age group as
135 worldview rapidly cements into attitudes of idiosyncratic belief systems that are, as has been previously
136 explained, extremely difficult to alter ^{38,46,68}. Recent research also indicates that embedding critical
137 reasoning as an antidote to worldview-amendment resistance may offer an effective pathway for individuals
138 to later re-assess their worldviews ⁵².

139 Lastly, as adolescents mature, they transfer their respect and social dependence from their parents and elders
140 to their peers and familiar others⁶⁵. This transfer is a hallmark of adolescence and represents a significant
141 social shift for science communicators both in terms of ‘potential for change’ that can be executed by that
142 age group as well as a coalescence of new social networks (ibid). Young people tend to have high levels of
143 social activism and this activism can lead to significant change throughout all levels of society⁷². Aside
144 from radical social adjustments, young people also implement gradual change as they secure relationships,
145 find employment, enrol to vote and exercise their rights as adults through what they buy, who they associate
146 with and how they manage their lives^{73,74}. Good governance depends, in many ways, on ensuring our youth
147 are successfully transferred from childhood to adulthood and are able to find a place for themselves in
148 society. Teaching them about climate change – both as a science and a wicked problem – will ensure they
149 are prepared to engage with it successfully, and could also drive much-needed social coalescence on this
150 issue⁵⁶.

151 This paper explores the suitability of this age group for science communication interventions toward
152 improving their understanding and preparedness for the future. To this end, we attempt to determine the
153 opinion signals of this age group in central urban centres both in comparison to their adult populations as
154 well as to the scientific consensus. We also endeavour to determine how worried our early adolescents are
155 with the issue of climate change as a measure of public concern. The tasks of adolescence are, of
156 themselves, quite daunting and anxiety-ridden without the pressure and uncertainty of climate change⁶⁵. As
157 adults, it is our duty to prepare young people for adulthood and to listen to their anxieties as a measure of
158 their over-all emotional and mental well-being. Assessing 12 to 13-year-olds on their opinions related to
159 climate change, therefore, becomes quite meaningful in broader social terms and may provide, for science
160 communication professionals, a heretofore unexplored pathway for climate science communication.

161 Objectives and Hypotheses

162 The overarching objective of this study is to determine the current opinion state of 12 to 13-year-olds with
163 regard to the three arenas of worry (worry: is it something to worry about), the cause (human: is it
164 anthropogenic), and its imminence (now: is it happening now) in relation to climate change and how these
165 opinions influence one another (H1), and differ across country, school, gender, and preference of discipline
166 (H2). Further, we review adult opinions in relation to climate change to investigate differences between the
167 early adolescent and their respective adult population (H3). Lastly, we discuss the alignment of early
168 adolescent opinions (worry, human and now) with the scientific consensus on climate change as a potential
169 target for science communication interventions.

170 As such, this study explores the following hypotheses:

- 171 • H1: There is an influence of the different opinions (worry, human and now) on one another (*H0: There is no influence of the respective opinions on one another*)
- 172 • H2: The opinion of early adolescents on climate change differ based on demographic factors, such as
173 country, gender, school, and disciplinary preference. (*H0: There is no difference in the opinion of
174 early adolescents based on demographic factors.*)
- 175 • H3: The opinion of early adolescents on climate change is different from [or higher than] the opinion
176 of adults in the same country. (*H0: There is no difference between the opinion of early adolescents
177 and adults in the same country.*)

179 Opinions – a synthesis of what adults currently believe

180 Before examining new data collected on the climate change opinions of early adolescents (12 to 13-year-
181 olds), we first outline the current state and understanding of adult public opinion on climate change. While
182 this paper is interested in, and reports on new data about, the opinions of the early adolescent, 12 to 13-year-
183 old, age group, there is limited existing data on the opinions of this group (likely due to the impracticalities
184 and challenges of research ethics of surveying children’s opinions)^{6,75,76}. As such, we collated the opinions

of adults for the same themes (worry, cause, and imminence of climate change: ‘worry’, ‘human’ and ‘now’) from large opinion studies in order to compare adults to early adolescents as a measure of contrast; particularly in relation to worldview. Since adult opinions relating to climate change are well-studied and typically remain stable over time, they provide a useful group for comparison – not least if anticipated influences of adults over early adolescents (and their worldview) are observed to be less powerful than we may expect.

Opinions of adults on climate change vary from nation to nation^{77,78} – and fluctuate within those nations over time, also^{20,79}. Determining the opinion of adults in relation to climate change allows science communicators to assess communication strategies and examine internal and external influences on opinions within communities (local to global) and monitor changing attitudes and perceptions. This process refines the science communication discipline and offers worthwhile insights into improving strategies for climate change as well as implementing strategies in other areas or in other science-related issues (e.g. GMOs, vaccinations). Although many surveys have been undertaken to monitor opinion in relation to climate change, there are differences in how they are constructed and how respondents are recruited. One difference is whether the response is yes/no or scaled on a preferential Likert scale (e.g. ranging between strongly agree to strongly disagree) (Leviston, Price, & Bishop, 2014). Such measurement differences make comparisons of results between surveys difficult. We can, however, see signals in those results that serve to inform science communicators and strengthen communication strategies within those respective countries. For some surveys, the data collection is across nations and national comparisons are made easier. Unfortunately, although opinion data has been collected over time from many nations, some countries lack sufficient data on the issue to gain more than cursory insights.

To establish a framework on which we can compare early adolescent opinions related to climate change, we looked at adult opinion data from the countries where we collected early adolescent data: Australia and Austria (as part of a larger research project investigating serious gaming interventions). Overall, Australians show that there is an influence of worldview with regard to climate change; political affiliation is a predictor of climate-related opinion^{55,81} and there is a strong sceptic faction in Australia⁸². While Australia has a plethora of literature on adult’s opinions with large-scale surveys going back to the early 1990s^{83,84} literature on public opinions related to climate change in Austria, according to Rhomberg, ‘*is scarce and often focuses on Alpine regions*’⁸⁵. Although this might be the case, Austria does show a very strong concern for issues related to climate change with 70% perceiving climate change as the world’s most significant problem (European Commission, 2014) and, following a recent EU-wide poll, 68% of Austrians consider climate change a ‘very serious problem’⁵. This concern reflects the amplified warming that Austria is currently experiencing in comparison to most other European countries⁸⁷ but it does not provide much insight into the nuances of public opinion, such as age, gender, education or relevant socio-cultural influences. Since the opinion signal from Austria is not as robust as from other EU nations, we have included opinions from France, Germany, Italy, the UK and Norway as a proxy measure in lieu of more specific opinion data from Austria and to obtain some understanding of European opinions as a whole (particularly as they are all long-term members of the European Union, are politically-significant EU members and/or are situated very close to Austria).

Differences among the countries of Europe are quite well-researched and -understood. France Norway, the UK and Germany have very strong support for opinion related to climate change^{1,88} with Italy also demonstrating relatively high concern, albeit behind current economic concerns^{89,90}. In France, all major candidates in the last French presidential election supported efforts to mitigate and adapt to climate change. Norway, although a high emission-per-capita nation, lacks the polarized nature that is evident in Australia and the US – and strongly identifies as climate-friendly⁹¹. The UK, although having a lower political impetus to address climate issues than other nations, has a strong environmental identity at the individual level. Germany, as an early-advocate for emission reduction⁴¹, is a world leader in political efforts to develop the climate accord and, according to Schäfer, the ‘*dismissive segment*’, which in the United States

233 *and Australia most strongly believes that climate change is not occurring or not caused by humans, is non-*
 234 *existent in Germany'* ⁸⁸. Opinion data from the United States has also been included for comparison of the
 235 EU data with a non-EU Western nation.

236 Opinion surveys have tended to measure the extent to which the public is worried or concerned, whether
 237 climate change is caused by human actions, and whether the climate is already changing. Data across these
 238 three dimensions are presented in the following sections.

239 Are people worried about climate change?

240 *Adult opinions – worry, now and human*

241 For the opinion on whether climate change is something to worry about, the European countries all show
 242 stronger positive alignment with this opinion than Australia or the US (Chart 1a). For correlation to opinion
 243 topics (worry=worry, cause=human, imminence=now), please see Appendix 1. The opinion on the
 244 anthropogenic nature of climate change is quite different across the countries (Chart 1b). Australia indicates
 245 a stronger opinion toward the influence of human-induced climate-change than the US but, again, the
 246 European countries all show much higher consensus with this opinion. For the opinion on whether climate
 247 change is happening now (Chart 1c), a greater proportion of Australians believe it is happening now than
 248 their US counterparts – although the proportion of people in Europe holding this opinion is higher still.
 249 Overall, we see that opinions in Europe are generally more aligned with evidence for climate change
 250 provided by the scientific consensus compared to Australia and the United States (which is generally lower
 251 again than Australia). For tables of adult data in relation to opinion topics (worry=worry, cause=human,
 252 imminence=now), please see Appendices 1 and 2.

Fig a.

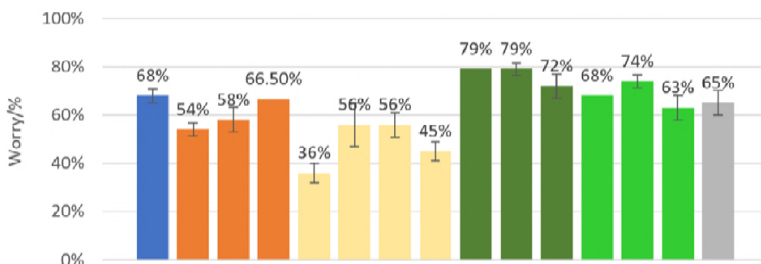


Fig b.

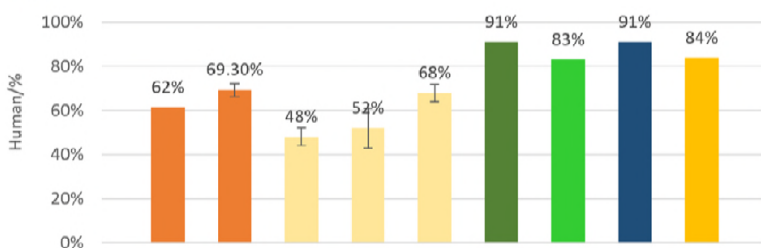
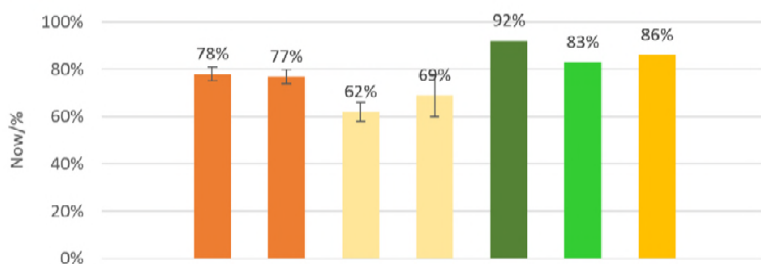


Fig c:



253 ■ Australia ■ United States ■ France ■ Germany ■ United Kingdom

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Figure 1: Collation of adult opinions in developed countries on whether (a) climate change is something to worry about (b) climate change is caused by human and (c) climate change is happening now. For data sources see Appendix 2. Error bars indicating uncertainty intervals as

reported by the data sources have been included when available. The year in which each survey was conducted is shown below each survey result. For further details see Appendices 1 and 2.

Materials and methods

To test the hypotheses, an opinion survey was created based on a previous survey by the primary researcher³⁸ and administered to first-year secondary students at six inner-urban high schools in Austria (in February-March, 2017) and Australia (June-August, 2017). This opinion survey, as previously mentioned, was part of a larger research project examining the role of serious-gaming interventions to improve climate literacy in the 12 to 13-year-age group (ethics protocol number: 2015/583). The survey was administered within the scheduled science class time (45-50 minutes) and was approved, as per the requirements for this research project, both by the relevant education departments and the ethics committee at the Australian National University. All protocols were followed in accordance with the requirements (ethical approval, anonymisation of the data, certifications for working with children/vulnerable people were met, and obtained permissions were stringently vetted: removing any participants where permission was not obtained).

Schools and Students

The research catchment criteria for this study depended on schools being within a <10km driving proximity to the central business district and their status as secondary public school in an inner-urban setting. The selection of the school depended, as a requirement from the respective departments of education in Australia and Austria, on whether the school director and head of science would be willing to participate in this research. According to the requirements and procedures, 6 schools agreed to participate in this study (2 in Vienna, Austria - Coded as VHS1 and VHS2 - and 4 in Australia: 2 in Sydney - coded as SHS1 and SHS2 - and 2 in Canberra - coded as CHS1 and CHS2). All schools taught in the 'mother-tongue' of their respective nationalities (i.e. German in the Austrian schools and English in the Australian schools) and follow the state-regulated curriculum of their respective education departments.

The students were 12-13 years old and all first-year secondary students. A total of 834 students took part in the survey with a final 457 (207 (45.3%) females, 245 (53.6%) males, and 5 (1.1%) other) being eligible for final inclusion and analysis. Eligibility depended on approval from the department of Education, and the school, as well as parental and student approval, then participation in the study and valid responses to the survey.

Because the schools were 'state suburb' zoned (5 schools of 6) for their district or suburb (with one school allowing exceptional students to enrol)⁹², we are not able to provide precise demographic information (census data) due to privacy laws as this is likely to make identification of the participating schools possible. It is, however, useful to provide some background information^{92,93} and to note a few aspects of the demographics that may assist in interpreting the findings without compromising the privacy laws. To begin with, population density is higher in Vienna (176/ha) than in Sydney (27.6/ha) or Canberra (15.9/ha). CHS1 and SHS2 both had fewer citizens in the selected age group (12-13 years). Austrian citizens had a higher proportion of adults with only minimum-requirement education (age approx. 16). CHS1, VHS1 and VHS2 all had far higher non-mandatory secondary levels of attainment (approx. 18 years). CHS1, CHS2, SHS1 all had significantly higher tertiary levels of attainment (Bachelor and above). Canberra citizens have far higher 'country of birth' percentages than Sydney or Vienna and have significantly lower net immigration at present than the other schools. CHS1 had the lowest level of unemployment.

Survey

In the first three items, the students were asked to put in an anonymous tracking code, their gender and preferred discipline. Following this, the next three items were Likert-style questions pertaining to their personal opinion with regard to their worry (is climate change something to worry about), the cause (is climate change caused by humans), and its imminence (is climate change happening now). The Likert scale ranged along a five-point scale:

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No – Probably not – Maybe – Probably yes – Yes

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For analyses, the Likert scale was converted to a numerical scale with No = 1, Probably not = 2, Maybe = 3, Probably yes = 4, and Yes = 5.

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Statistical Methods

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Multiple regression models (IBM SPSS statistics 23.0) were used to analyse the respondents opinions about climate change. There were 3 variables, ‘Worry’, ‘Human’, and ‘Now’ considered as the response variables (5-point Likert-scale as described above) as well the main effects of country, school, subject preference, and gender. Also, 2-way interactions for Country/School, Country/Subject Preference, Country/Gender were considered in the analyses. Coding for ‘Subject Preference’ explanatory variable (subjects from the respective schools: Austrian and Australia) were coded into their respective subject counter-part from the other school (i.e. ‘Science’ in Austria is separated into ‘Physics’, ‘Chemistry’, ‘Biology’ – all of these are distinctly different subjects in Austria but are taught under one subject ‘Science’ in Australia)) (Appendix 3).

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The overarching analysis approach, therefore, consisted of the following stages:

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1. Descriptive statistics on trends in overall opinion of early adolescents.
2. Multiple regression was conducted to determine the relationship between the response and the predictors

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For the comparison on adult vs respondent opinions, and the between-country comparison, we calculated the comparisons of proportions using the ‘N-1’ Chi-squared test as recommended by Campbell (2007) and Richardson (2011). The confidence interval was calculated according to the recommended method given by Altman et al. (2000).

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Results

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Descriptive Data

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Opinion data: climate change is something to worry about

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In total, 302 students, corresponding to 66.1% of the students ($n = 457$), were firmly of the opinion that climate change is something to worry about (response = yes) and 102 students, corresponding to 22.3% of the students were of the opinion that climate change is something we should probably worry about (response=probably yes) (Table 5). The total positive response was 88.4%. The remaining responses (responses = ‘maybe’, ‘probably not’ and ‘no’) totalled 53 students and 11.7%, respectively.

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Table 1: Overview of per school responses to the question: ‘In your opinion, is climate change something we should all worry about?’ Coding: VHS1 and VHS2: Vienna High School 1 and 2, respectively. SHS1 and SHS2: Sydney High School 1 and 2, respectively. CHS1 and CHS2: Canberra High School 1 and 2, respectively.

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Response	VHS1 n/ (%)	VHS2 n/ (%)	SHS1 n/ (%)	SHS2 n/ (%)	CHS1 n/ (%)	CHS2 n/ (%)
Yes	25 (58.1)	22 (62.9)	75 (60.0)	52 (68.4)	55 (67.9)	73 (74.5)
Probably yes	11 (25.6)	8 (22.9)	31 (24.8)	16 (21.1)	16 (19.8)	20 (20.4)
Maybe	6 (14.0)	5 (14.3)	13 (10.4)	2 (2.6)	7 (8.6)	4 (4.1)
Probably not	1 (2.3)	0 (0.0)	3 (2.4)	4 (5.3)	3 (3.7)	0 (0.0)
No	0 (0.0)	0 (0.0)	3 (2.4)	1 (1.3)	0 (0.0)	1 (1.0)
Sum/country total: ‘yes’, ‘probably yes’		66 (85.3)				338 (89.2)

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Opinion data: that climate change is caused by humans

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In total, 253 students, corresponding to 55.4% of the students, were firmly of the opinion that climate change is anthropogenic in nature (response = yes) and 123 students, corresponding to 26.9% of the students

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338 were of the opinion that climate change is caused by humans (response=probably yes) (Table 6). The total
 339 positive response was 82.3%. The remaining responses (responses = 'maybe', 'probably not' and 'no')
 340 totalled 81 students and 17.7%, respectively.

341 *Table 2: Overview of per school responses to the question: 'In your opinion, do you think humans cause climate change?'* Coding: Same as for
 342 *Table 1.*

Response	VHS1 n/ (%)	VHS2 n/ (%)	SHS1 n/ (%)	SHS2 n/ (%)	CHS1 n/ (%)	CHS2 n/ (%)
Yes	21 (48.8)	16 (45.7)	68 (54.4)	42 (55.3)	36 (44.4)	70 (71.4)
Probably yes	15 (34.9)	5 (14.3)	30 (24.0)	21 (27.6)	28 (34.6)	24 (24.5)
Maybe	2 (4.7)	7 (20.0)	18 (14.4)	7 (9.2)	11 (13.6)	4 (4.1)
Probably not	2 (4.7)	2 (5.7)	7 (5.6)	1 (1.3)	1 (1.2)	0 (0.0)
No	3 (7.0)	5 (14.3)	2 (1.6)	4 (5.3)	5 (6.2)	0 (0.0)
Sum/country total: 'yes', 'probably yes'	57 (71.9)			319 (84.1)		

343 *Opinion data: that climate change is happening now*

344 In total, 268 students, corresponding to 58.6% of the students ($n = 457$), were firmly of the opinion that
 345 climate change is happening now (response = 'yes') and 124 students, corresponding to 27.1% of the
 346 students were of the opinion that climate change is probably happening now (response = 'probably yes')
 347 (Table 7). The total positive response was 85.7%. The remaining responses (responses = 'maybe', 'probably
 348 not' and 'no') totalled 65 students and 14.2%, respectively.

349 *Table 3: Overview of per school responses to the question: 'In your opinion, do you think climate change is happening now?'* Coding: Same as
 350 *for Table 1*

Response	VHS1 n/ (%)	VHS2 n/ (%)	SHS1 n/ (%)	SHS2 n/ (%)	CHS1 n/ (%)	CHS2 n/ (%)
Yes	17 (39.5)	20 (57.1)	77 (61.6)	50 (65.8)	43 (53.1)	61 (62.2)
Probably yes	15 (34.9)	7 (20)	36 (28.8)	19 (25)	22 (27.2)	25 (25.5)
Maybe	8 (18.6)	7 (20)	8 (6.4)	6 (7.9)	14 (17.3)	8 (8.2)
Probably not	0 (0.0)	0 (0.0)	2 (1.6)	0 (0.0)	0 (0.0)	2 (2.0)
No	3 (7.0)	1 (3)	2 (1.6)	0 (0.0)	2 (2.5)	2 (2.0)
Sum/country total: 'yes', 'probably yes'	59 (75.8)			333 (87.3)		

351 *Statistical Analysis*

352 *Effect of opinions, country, school, gender and subject preference on opinions about climate change*

353 The results of the multiple regression showed that all opinions were predictors of one another with
 354 statistically significant main effects of Human ($\chi^2 = 47.98$, $df = 1$, p -value = $<.001$) and Now ($\chi^2 = 14.12$, df
 355 $= 1$, p -value = $<.001$). Both, Human (Model 2) (coef = 0.246, SE = 0.036) and Now (Model 3) (coef =
 356 0.155, SE = 0.041) were positively related with the response Worry (Model 1). If a respondent had the
 357 opinion that climate change was something to worry about, this would likely predict that they also had the
 358 opinion that climate change was anthropogenic and was happening now (Table 8). Results for common
 359 explanatory variables are shown below for all response models.

360 *Table 4: Response variable association with the statistical models*

Model	Response Variable	Explanatory variable	
		Opinion	Common
1	Worry	Now, Human	Country, School, Gender, Subject Preference
2	Human	Now, Worry	
3	Now	Worry, Human	

361 *Model 1: Common effects on opinion that climate change is something to worry about*

362 The results of the statistical analysis using multiple regression showed no significant main effect or 2-way
363 interactions with any of the explanatory variables: country ($\chi^2 = 0.186$, $df = 1$, p -value = 0.667), school ($\chi^2 =$
364 10.248, $df = 5$, p -value = 0.69), gender ($\chi^2 = 0.011$, $df = 1$, p -value = 0.916), or subject preference ($\chi^2 =$
365 17.108, $df = 10$, p -value = 0.072).

366 *Model 2: Common effects on opinion that climate change is caused by humans*

367 The results of the statistical analysis using multiple regression showed that although there is no difference in
368 the main effect of opinion between the countries, per se, 2-way interaction between Country and Gender
369 indicated that females in Austria ($n = 33$, mean = 4.33, SE = 0.162) are more likely than males in Austria (n
370 = 48, mean = 3.93, SE = 0.140) to have the opinion that climate change is anthropogenic ($\chi^2 = 9.530$, $df = 1$,
371 p -value = <.003). Additionally, males in Australia ($n = 200$, mean = 4.43, SE = 0.074) are more likely to
372 have this opinion than females in Australia ($n = 176$, mean = 4.14, SE = 0.081; $\chi^2 = 9.530$, $df = 1$, p -value =
373 <.003). Although the differences between means (i.e. 4.33 v. 3.93 and 4.43 v. 4.14,) in context of the Likert-
374 scale, would be rounded to an integer of 4 (correlating to 'probably yes') and may seem marginal on the
375 measurement scale, it is worthy to note that this prediction signal represents a difference between these
376 groups of 8.0% (more female Austrians than male Austrians) and 5.8% (more male Australians than female
377 Australians), respectively.

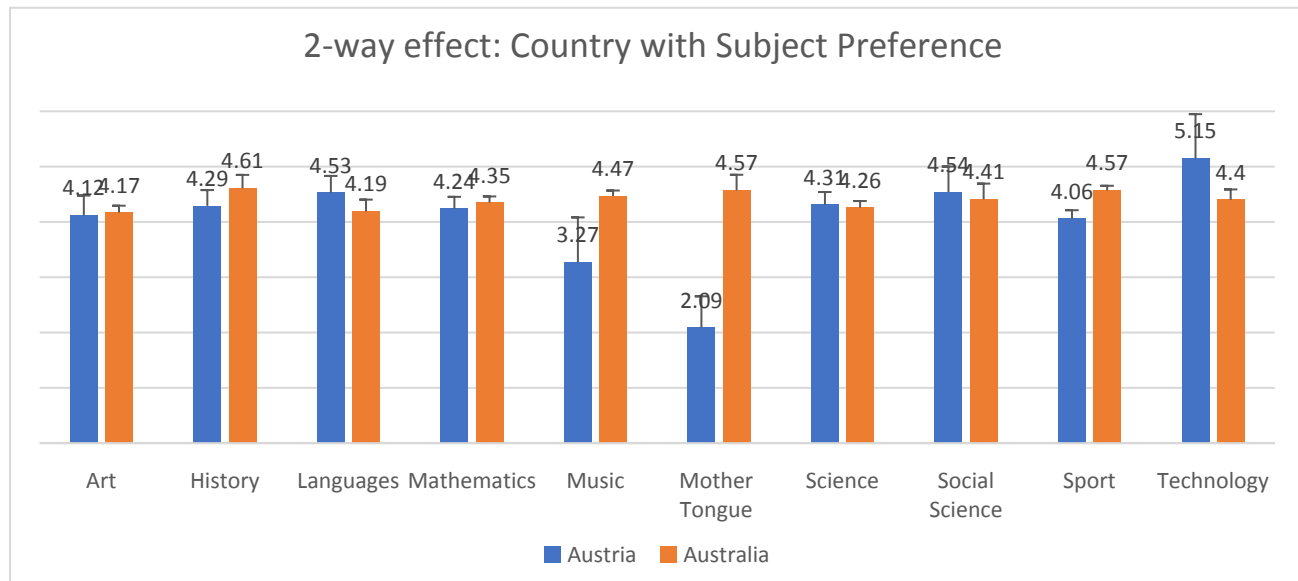
378 Subject Preference was also a predictor ($\chi^2 = 18.475$, $df = 10$, p -value = <.047), in that students who
379 preferred certain subjects would more likely have the opinion that climate change was caused by humans
380 with students who preferred Music ($n = 9$, mean = 4.65, SE = 0.288), Art ($n = 47$, mean = 4.50, SE = 0.143),
381 Science ($n = 59$, mean = 4.35, SE = 0.124) or Sport ($n = 119$, mean = 4.19, SE = 0.090) more likely to have
382 this opinion than those who preferred Technology ($n = 19$, mean = 3.93, SE = 0.214), History ($n = 20$, mean
383 = 3.81, SE = 0.207). As with the above, although the actual difference between the means for each of these
384 subject preferences does not appear profound when viewed in the context of the Likert-type scale (lowest
385 subject rating 3.81 and highest subject rating 4.65) this difference, when applied to the sample population,
386 represents a 16.8% difference (i.e. 16.8% more music, art, science and sport students think that climate
387 change is anthropogenic than technology and history students).

388 *Model 3: Common effects on opinion that climate change is happening now*

389 The results of the statistical analysis using multiple regression showed that 12 to 13-year-old Austrians ($n =$
390 83, $\chi^2 = 4.375$, $df = 1$, p -value = <.036; mean=4.06, SE = 0.150) were somewhat less likely to have the
391 opinion that climate change is happening now than their 12 to 13-year-old Australian peers ($n = 380$, $\chi^2 =$
392 4.375, $df = 1$, p -value = <.036; mean=4.41, SE = 0.057). In addition, there was a 2-way interaction between
393 Country and Subject Preference ($\chi^2 = 18.514$, $df = 9$, p -value = <.030), with students from Austria who
394 preferred Mother Tongue ($n = 1$, mean = 2.09, SE = 0.812) and Music ($n = 2$, mean = 3.27, SE = 0.565) to
395 be less likely to think that climate change was happening now (Chart 1) than their Australian peers who
396 preferred Mother Tongue ($n = 66$, mean = 4.57, SE = 0.098) and Music ($n = 8$, mean = 4.47, SE = 0.283). In
397 this case, when viewed in context with the Likert scale, the means range from 2.09 through to 4.47 and
398 reflects a range difference of 47.6% (i.e. 47.6% more Austrian mother-tongue or music students were of the
399 opinion that climate change is happening now than their Australian peers). This last interaction, Country
400 with Subject Preference, can be explained by the low value for n in these categories.

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Figure 2: Subject preference effects on opinion that climate change is happening now. Covariates appearing in the model are fixed at the following values: Worry=4.51; Human=4.27. Please note that the estimated marginal means are based on the model, therefore, it could be possible that the mean value for country*Subject_preference is bigger than maximum value (e.g. Technology=5.164) i.e. $\text{Now} = \text{intercept} + \text{country} + \text{Subject_pref} + \text{country} * \text{Subject_pref} + \text{worry} * B(\text{worry}) + \text{Human} * B(\text{human}) = 2.753 + 0.128(\text{for country 1}) + 0.6240(\text{country}(1) * \text{Subject_pref}(8)) + 0.194 * (4.51 \text{ (fixed value)}) + 0.184 * (4.27 \text{ (fixed value)}) = 5.164$



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Comparison of early adolescents with respective or proxy adult population

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The following table provides an overview of early adolescent opinions in comparison to their respective (or proxy) adult population. Both student groups in Australia and Austria show a strong alignment with one another, a stronger positive worry level than Australian (63.28%) and European (71.32%) adults which strongly supports the scientific consensus in the Worry opinions related to climate change. With regard to the Human and Now opinions, the Australian student group demonstrate a much higher level of concern than their Austrian peers and the European and Australian adults. In addition, more 12 to 13-year-olds in this study report the opinion that climate change is something to worry about (85.3% Austrian respondents vs 71.32% Austrian adults/89.2% Australian respondents vs 63.29% Australian adults) and this is further supported in the findings with students responding more definitely (yes= 63.83%) to this opinion than to the Human (55.5%) or the Now (56.33%) opinion. Australian 12 to 13-year-olds in inner urban public-school environments do not reflect the same opinions for Worry and Human-causation as their respective adult population – our respondents were significantly more likely to think climate is something to worry about (89.2% respondents vs 63.28% adults) and is caused by humans (87.3% respondents vs 63.69% adults) with a lower difference for the opinion that climate change is happening now (84.1% respondents vs 77.72% adults). In comparison, although Austrian 12 to 13-year-olds show a higher level of opinion for worry to their adult population (85.3% respondents vs 71.32% adults), they have significantly lower differences for the opinion Human (71.9% respondents vs 87.24% adults) and Now (75.8% vs 87.00%) as their respective European adult neighbours.

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Table 5: Comparison of 12-13 year old adolescents with respective adult population. @Data has been averaged from 2 or more surveys *P<0.0001 **P = <0.01 ***no significant difference

	Austria			Australia			Between-country comparison	
	Adolescents /%	Adults /%	Diff/ (adolescents – adults) /%	Adolescents /%	Adults /%	Diff/ (adolescents – adults) /%	Difference (Austrian – Australian) adolescents /%	Diff/ (Austrian – Australian) Adults /%
Worry	86.1	71.32	+13.98**	89.1	63.28@	+25.92*	-3.9***	+8.04@*
Human	72.9	87.24	-11.44**	82.1	63.69@	+23.61*	-11.5**	+23.55@*
Now	75.7	87.00@	-15.34*	87.6	77.72@	+6.38**	-12.2**	+9.28@*

Discussion

The study explored the opinion, and determinants, of 12 to 13-year-olds in relation to climate change, across the three arenas of worry, imminence, and human-causation. In light of the findings that each of the opinions (worry, human and now) predict one another, we reject the H1's null hypothesis that there is no influence on the opinions for one another. The response for this age group in these areas indicates that the vast majority shares the concern that climate change is something to worry about, is caused by humans and is happening now –and these opinions relate predictably to one another.

With regard to the findings on the influence of demographic factors on opinion about climate change, we partially reject H2's null hypothesis there is no difference in the opinion of early adolescents based on demographic factors, such as country, school, gender and subject preference. This is because some demographic factors correspond with significant differences in opinion on climate change, while others do not.

Lastly, as part of a broader research question, we determined differences between early adolescents and adults in the same (or proxy) country. We found that more adolescents than adults in Australia are concerned about climate change, whereas the comparison was more variable in Austria (and proxy countries).

Overall, we have found that opinions in the 12-13 year age group show strong pro-climate sensitivities – and the vast majority think climate change is something to worry about, is caused by humans and is happening now. The relation of the opinions to one another, though not surprising, is an important finding as it may allow us to extrapolate the same relationship in studies that have looked at only one aspect of these opinions. For science communicators, however, the demographic influences that affect an individual's opinion are important and may offer insights into unexplored interventions and communication strategies.

Demographic factors and opinion

Climate change is something to worry about

In the statistical analysis, we see that the opinion for Now and Human strongly increases the opinion for Worry – meaning that those students who think that climate change is happening now and caused by humans are far more likely to be worried about climate change. These results are important as this suggests that worry regulation and emotional support would be worthy interventions in this age group – particularly those that foster hope and concern^{56,94} as these are associated with stronger climate change beliefs, increased engagement and life satisfaction²⁸. This also suggests, due to the association of worry with climate change, that interventions that focus on causes (teaching the physical science basis: mechanisms, processes and basic climate science) instead of consequences (highlighting the impacts; sea-level rise, increased temperatures, extreme weather events) may diminish negative emotions associated with threats⁵¹ and allow individuals to engage with climate change in a safer and more certain cognitive space of 'normal' science (as opposed to the 'post-normal' or wicked aspects of climate change). Establishing the 'normal' aspect of climate science may provide an intellectual scaffold to engage with that wickedness intellectually at a later age. Finally, these results also strongly reinforce previous research on emotional reasoning and associated changes in early adolescence which indicate that this age group are beginning to use 'objective', abstract-reasoning information to perceive threat^{71,95}.

Climate change is caused by humans

Surprisingly, although there was no signal in the statistical analysis for country with regard to the opinion for Human (meaning that it didn't matter which country the student came from with regard to the opinion that climate change is caused by humans) this influence became significant when gender was included in the analysis. Although research shows that late adolescent and adult females are more likely to be pro-environmental than males^{96,97}, our study suggests that this is not always the case, with Australian males reporting, more than their female peers, the opinion that climate change is caused by humans. Austria's

474 results supported the results of many previous studies with females showing a stronger opinion that climate
475 change is anthropogenic than males. Of course, other factors may play a role and the lower number of
476 Austrian respondents might suggest a stronger signal within a smaller demographic (community influences
477 that we are not aware of, for example: immigration, zoning, lower school funding/resources). These
478 findings suggest that research and tailored interventions aimed at targeting gender may be useful in
479 promoting a better understanding of climate change. For example, serious gaming with a climate science
480 topic may provide gender-specific game-play that responds to known gender differences – or, more usefully,
481 are derived from game analytics that interact at the individual-student level to tailor learning to the learner
482 needs.

483 Lastly, students who preferred Music, Art, Science, and Sport were more likely to support the opinion that
484 humans are causing climate change than students who preferred Technology and History. The preference
485 for science makes some sense, although previous studies in adults have argued that scientific literacy may
486 decrease an individual's support for this opinion, if they are ideologically predisposed to reject implications
487 of climate change, e.g. economic or social changes^{58,68}. However, other studies rejected these findings as
488 they found that the reported scientific literacy was not climate-science-specific or the literacy was self-
489 assessed and this is problematic as people require an understanding of a scientific field in order to make an
490 informed choice or, in the case of self-assessment, often claim more understanding than they really have
491^{51,68,98}. In addition, Shi et al. (2015) suggest that scientific literacy may not be an adequate predictor of
492 climate literacy as expert knowledge is domain-specific and may not encompass other, unique areas of
493 expertise. The preference for Music and Art may also align with communities where pro-environmental
494 attitudes are common and strongly supported and engaged with. The preference for Sport is quite surprising
495 and, aside from a (perhaps) more-frequent interaction with nature i.e. outdoor sports, weather-dependent
496 play, this finding requires more investigation as it may indicate a nature-deficit influence⁹⁹. The lower
497 opinions for Technology and History are, again, surprising. A rationale for this might be found in further
498 research or, as mentioned above, a larger sample group across a broader swathe of the 12 to 13-year-age
499 group. Importantly, though, while these differences were statistically significant, all mean ratings from each
500 subject area were situated between 'maybe' and 'definitely yes', so the effective difference in opinion, while
501 noteworthy, does not indicate a profound difference in opinions based on subject preference.

502 *Climate change is happening now*

503 The most surprising finding of this study is the stronger opinion amongst 12 to 13-year-old Australian
504 public-school students living in central urban districts that climate change is happening now than is shared
505 by their Austrian peers (84.1% Australian respondents vs 71.9% Austrian respondents). It is especially
506 remarkable that, in light of the amplified warming that is taking place in Austria^{85,100}, that Austrian students
507 are less likely to have the opinion that it is happening now. In addition, the 2-way interaction between
508 Country and Subject Preference, Australian students who prefer Music and Mother Tongue, were
509 significantly more likely to think that climate change is happening now than their Austrian peers who prefer
510 these subjects, with the means for each subject area representing a spread from 'probably not' (Austria) to
511 'probably yes' (Australia).

512 *Comparison of adolescents with adults*

513 Although we might anticipate a strong alignment with the respective political position on climate change in
514 each country (i.e. strong positive adolescent and adult opinions in Austria in line with EU climate policy and
515 weaker positive adolescent and adult opinions in Australia in line with weaker Australian climate policy),
516 we found that Austrian student were less likely to have the opinion that climate change is happening now
517 and is caused by humans – both in comparison to their proxy adult population (Human: 75.8% Austrian
518 respondents vs 87.24% Austrian¹ adults; Now: 71.9% Austrian respondents vs 87.0% Austrian¹ adults) and
519 to their Australian peers (Human: 75.8% Austrian respondents vs 87.3% Australian respondents; Now:

¹ Where opinion data is not available for Austria proxy data has been used (e.g. neighbouring EU countries)

520 71.9% Austrian respondents vs 84.1% Australian respondents). This finding challenges the anticipated
521 influence of their adult populations – especially as the comparison shows Australian 12 to 13-year-olds think
522 climate change is something to worry about, is caused by humans and is happening now, more than their
523 adult cohort do (Worry: 89.2% respondents vs 63.28% adults; Human: 87.3% respondents vs 63.69%
524 adults; Now: 84.1% respondents vs 77.72% adults) – although Austria 12-13 year olds are more worried
525 than their respective adult population (Worry: 85.3% Austrian respondents vs 71.32% Austrian¹ adults), they
526 show lower opinion levels for Human (75.8% respondents vs 87.24% adults¹) and Now (71.9% Austrian
527 respondents vs 87.00% Austrian¹ adults) than their proxy adult population.

528 There may be differences in culture or lifestyle between adolescents in Austria and Australia, such as
529 differences in population density or interactions with nature ¹⁰¹ that lead to the observed differences in
530 opinion. However, it would be likely to see any such effect reflected similarly in the adult populations if it is
531 simply an effect of place. Instead, if there is no methodological or measurement error responsible for the
532 difference, then these results indicate there is an interaction between the adolescent experience and place
533 which shape the attitudes. For example, curriculum content or norms around adolescents' awareness of
534 climate change or other key policy issues. Curiously, both Australian and Austrian 12-13 year olds show
535 higher rates of reporting the worry opinion when compared to their respective adult populations – and with a
536 stronger positive response than for the other opinions (now and human). This worry signal is an important
537 one as it suggests that, although Austrians in this age group are attuned to the emotional aspect of climate
538 change as a threat, they do not possess the fundamental understanding of climate change processes to
539 recognise the major dimensions of climate change which make it worthy of worry; these are both the
540 imminence of the threat (now), and the fact that the observed warming and climatic changes are resulting
541 from human interference in the climate system (human).

542 Limitations to this study

543 It is necessary to note that certain biases may have influenced the data and affected the findings. The first is
544 that the selected students were from a total of six schools, and as a result cannot be considered a
545 geographically or demographically representative sample of either country. Despite this, the results are
546 useful, especially as data on the 12 to 13-year-old age group is scarce in the literature. It would be beneficial
547 for future studies focused on early adolescents to adopt compatible methods to allow for aggregation of data,
548 developing a more robust data set. One of the barriers to more geographically and demographically
549 representative data from 12 to 13-year-olds is the (necessary) challenge posed by research ethics of working
550 with young and vulnerable people. All participants required approval from the school, their teachers, the
551 parents, and the students themselves. Those who maintain climate-friendly attitudes are, therefore, more
552 likely to participate in this research than those who do not. The level of teacher engagement was, perhaps,
553 the most influential of all the potential biases for the teachers were the essential driver behind participation
554 numbers in each class. The author observed that the teachers who were not enthusiastic had a far lower
555 number of participants in their class than those who were favourable towards the research. This observation
556 was apparent in anecdotal negative criticism of the project by those teachers who returned fewer
557 participation notes from their students and, in some cases, suggesting to the researcher that climate science
558 was not a 'settled' science. In addition, one of the schools in Vienna (VHS2) had parents that were very
559 sceptical about their child's involvement in a research project with 2 out of the 4 classes returning notes that
560 denied permission. Many of these parents were new residents in Vienna (very recent arrivals), so it was
561 difficult to discern whether declining to participate was on account of their vulnerability as new residents or
562 due to negative attitudes toward climate change. If the latter, then these important perspectives were not able
563 to be captured in the study. Curiously, nearly all permission notes were returned by the parents in the
564 Austrian schools (even those stating that their child could not participate) whereas just over half were
565 returned from Australian schools (with nearly all saying their child could participate) even though the
566 recruitment process had been the same. The researcher speculates whether the unreturned notes in Australia
567 are in lieu of a returned note that does not allow their child to participate or a lack of procedure between the

568 school and home that results in lost or misplaced permission notes – or a mix of both. These unavoidable
569 challenges of working with schools and their adolescent students are useful for other researchers to note
570 when engaging with similar samples for future research.

571 Implications of this study

572 As worldview plays such a significant role in the opinions and behaviour of adults, the 12-13-year age-group
573 presents an opportunity for science communication intervention. While socio-cultural worldviews are still
574 nascent, and not strongly influencing opinion development, the intellectual scaffolding for understanding
575 climate science is far-more strongly developed at this age. The potential to improve an individual's
576 understanding of climate science as a basis for engaging with climate-friendly policy and advocacy, without
577 the bias of worldview, makes this age group an ideal target. In the 12-13-year age group, addressing the
578 'knowledge deficit' (being sufficiently informed on an issue i.e. climate science, in order to make an
579 informed decision)^{38,51,68} is a valid pathway for interventions as these individuals are all, without exception,
580 enrolled in school in order to be given the information, literacy, skills and intellectual tools they need to
581 enter society.

582 Although climate science is complex, this age group has already begun to cultivate the cognitive framework
583 that can allow them to intellectually process the different aspects of climate science – including feedbacks,
584 interactions, and scales. This is especially evident in the increased sense of worry they show if they do think
585 that climate change is happening and is caused by humans.

586 Conclusion

587 The potential for the 12 to 13-year-old age group as important targets for science-based climate change
588 education is clear. Not only do we have an age group whose opinions already align well with the scientific
589 consensus, we also have a group that could greatly benefit from well-designed science communication
590 interventions due to the stage of their intellectual development. Additionally, early adolescents are easy to
591 reach as they are all in school, and they are at the nascent stage of worldview construction. Improving
592 scientific literacy in relation to climate change could have immense social and political implications, such as
593 providing all young people with a fundamental understanding of the science of climate change, regardless of
594 the political ideology or social identity they will develop in the years ahead. Perhaps, if such a literacy
595 programme was properly implemented, we would have a general public that, regardless of worldviews and
596 belief systems, would share a good understanding of the science of climate change as the basis for public
597 and policy deliberations on relevant courses of action. Climate-science education of early adolescents offers
598 alternative intervention routes that avoid the worldview-based polarisation on the reality of climate change
599 which we have experienced in recent decades. Future climate science-educated adults could no more deny
600 the phenomena of climate change than they could deny the existence of their large intestines: both are
601 physical phenomena manifest invisibly in our everyday lives.

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