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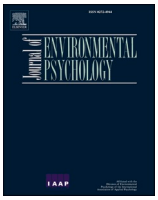

Young children's global climate change salience and comprehension: The effect of parental perception and communication

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ABSTRACT

Children are particularly vulnerable to global climate change (GCC), yet their reactions to GCC are largely unexplored. This study examines 5-8-year-old children's understanding of GCC and how salient it is to them. Specifically, we checked whether children's salience and comprehension of GCC varied with age and investigated the role of parents as primary socialization agents in these processes. In a sample of 312 child-parent dyads from Spain, we gathered data through structured interviews with children and standardized questionnaires completed by parents. Children's age was positively related to salience and comprehension of GCC, with a marked increase around age 7. When parents view GCC as more proximate in time, they communicate more frequently about GCC with their children. This, in turn, enhances children's awareness and understanding of GCC. Children's gender and parents' educational background, political views, and family income were not significantly linked to children's GCC salience or comprehension.

1. Introduction

Global climate change (GCC) is an increasingly salient concern. Scientific and technological advancements have provided a deeper understanding of the causes and consequences of GCC, along with a growing body of research on possible mitigation methods against its detrimental effects (Mi et al., 2019; National Aeronautics and Space Administration [NASA], 2023). The negative effects of GCC include long-term elevated temperatures, sea level rise, and increased frequency and severity of extreme weather conditions on Earth (Cianconi et al., 2020; Perkins et al., 2012). GCC also affects people's health, increasing the incidence of heat illnesses, vector-borne diseases, water-borne diseases, respiratory illnesses, and mortality caused by extreme climate events (World Health Organization [WHO], 2023). Possible psychological repercussions of GCC include increased anxiety and depression, elevated stress, sleep interference, and substance abuse (Cianconi et al., 2020; Clayton & Karazsia, 2020; Evans, 2019; WHO, 2022a, 2022b).

Children are especially vulnerable to GCC's negative consequences, leading to a greater accumulation of physical and psychological detriments (Evans, 2019; Sanson et al., 2019). However, young children's understanding of GCC is often limited (Ratinen, 2021; Shepardson et al., 2011; Teixeira et al., 2024). Most children are exposed to GCC information from different social agents (e.g., school, social media) without a clear understanding of its phenomena or its consequences, which may contribute to feelings of anxiety and fear (Ettinger et al., 2021). Thus, the study of children's comprehension of GCC is an important topic with implications for the design of better educational interventions to inform children about GCC while supporting their well-being (Trott, 2020). We contribute to research on GCC and young children by interviewing a younger age range (5–8 years) than previous studies. We focus on early childhood to provide insights about when children are cognitively prepared to understand GCC and how its salience (i.e., the importance children place on GCC) varies with age. We also evaluate potential relationships between parents and young children's salience and comprehension of GCC. In doing so, we consider parents' perceptions of GCC and communication about GCC with their children.

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1.1. Children's salience and comprehension of GCC

Young children's salience and comprehension of GCC remain relatively unknown (Hahn, 2021). Yet, younger groups are especially vulnerable to the current climate crisis (Ahdoot et al., 2024; Evans, 2019; Ma et al., 2022; Sanson et al., 2019). As GCC consequences worsen, younger children will likely confront increasingly harmful conditions throughout their development (Vergunst & Berry, 2022). Similar to previous studies, we conceptualize GCC comprehension as children's accurate knowledge of GCC and their ability to provide a correct definition (Ratinen, 2021; Teixeira et al., 2024). We are also interested in exploring the salience of GCC to young children. Salience refers to the prominence or importance of a topic in a person's mental processes (Fiske & Taylor, 2013). Thus, a salient topic stands out to an individual and is more likely to influence their attention, judgments, and behavior. Considering this, we define GCC salience as the importance children place on GCC as an environmental issue. We operationalize it as the spontaneous mention of GCC when queried in an open-ended probe about environmental problems. Therefore, GCC salience is related to other concepts that have been previously explored, such as children's awareness of GCC (Borg et al., 2019) or concern about GCC (Teixeira et al., 2024). To our knowledge, the salience of GCC among children has not been previously studied.

It is hard for the general public, let alone children, to build a nuanced understanding of GCC's complexities (Tobler et al., 2012). We already know that secondary school children's understanding of GCC is often inaccurate, and they tend to make mistakes when discussing its causes, consequences, and solutions. For example, their definitions of GCC are frequently simplified and centered on a subset of elements, such as changes in temperature and precipitation rates, instead of considering the phenomena as part of an interrelated whole (Shepardson et al., 2011). Other common mistakes found in a sample of children aged 10 to 13 include defining GCC as a normal change in weather conditions or mentioning ozone layer depletion as a cause or consequence of climate change (Teixeira et al., 2024). When asked whether a series of statements about GCC were true, Ratinen (2021) found that only half of a sample of 10- to 15-year-old children answered correctly.

Yet, children must also be considered key agents in mitigating GCC (Michelsen & Fisher, 2017). Young people's comprehension of GCC and the importance they attribute to it are crucial for facing the climate crisis. Most environmental education programs focus on increasing knowledge about environmental issues, including GCC (Ardoin et al., 2020). Although knowledge about environmental issues is a necessary condition for promoting ecological behaviors, it is not sufficient on its own (Broomell et al., 2015; Busch et al., 2019; Collado & Evans, 2023; Ienna et al., 2022; Schreiner et al., 2008). Importantly, there is still limited understanding of the age at which children acquire the cognitive abilities required to comprehend GCC, as most existing research has focused on adolescents' perceptions of GCC. Moreover, existing studies have considered relatively small samples of children with narrow age ranges. For instance, Borg and others (2019) examined 5-year-olds' environmental awareness, including their perception of how much human actions (e.g., the excessive use of vehicles) can harm the environment. About half of the 53 five-year-olds included in her sample had already developed such awareness. In a recent study with 10- to 13-year-old children, Teixeira et al. (2024) found that older children tend to have more precise knowledge of GCC than younger ones, become more interested in possible solutions, and are more concerned about its consequences. In other words, GCC seems to be a more salient issue to children as they grow up. However, it is still unknown at what point in the life span comprehension of GCC can emerge.

1.2. Parental role in Children's GCC salience and comprehension

In addition to learning more about at what age GCC becomes salient for children and when they can comprehend this phenomenon, it is valuable to examine what factors might contribute to GCC knowledge acquisition.

Socialization refers to social interaction processes through which children gain the knowledge and skills needed to adequately navigate their environment (Settersten, 2002). Knowledge and attitudes on various topics, such as political orientation (Jennings et al., 2009) and product consumption (Hsieh et al., 2006), are commonly developed through socialization processes. For children as young as five years old, parents contribute more to socialization than teachers or peers (Matthies & Wallis, 2015). Regarding environmental knowledge, most 5-year-old children report their parents as their main source of information (Borg et al., 2019). As children grow, peers become the primary influence on environmental learning, overtaking parents (Collado et al., 2017). Additionally, as children age and spend more time at school, teachers' influence plays an increasingly important role in environmental socialization (Corner et al., 2015; Valdez et al., 2017).

Insights about parental socialization of children's perceptions of GCC may be gleaned from research on relations between parents' and children's general environmental attitudes and behaviors. For instance, Chou et al. (2023) investigated GCC perceptions in a sample of fifty 5- to 18-year-olds and found that participants with a more accurate perception of GCC attended schools with better environmental education. Those with more accurate perceptions also had parents who engaged in more pro-environmental behaviors. Participants with lower socioeconomic status also demonstrated less accurate GCC knowledge.

Even though parents' behavior predicts children's attitudes and behaviors, it seems that parents' attitudes or concerns about GCC are not strongly associated with their children's perception of GCC (Hahn, 2021; Lawson et al., 2019). Grønhøj and Thøgersen (2012) found that parents' pro-environmental attitudes were not linked to their adolescent children's attitudes or behaviors, whereas parents' pro-environmental behaviors were positively associated with adolescents' pro-environmentalism. However, in a longitudinal study, Evans et al. (2018) found that mothers' pro-environmental attitudes during early childhood (6-7-year-olds) predicted their children's ecological behavior 12 years later, showing that the effect might only be noticeable over time. It may also be that pro-environmental behaviors are easily observable (and imitated) by children, while attitudes are less discernible. Another possible explanation is that parents need to explicitly communicate their environmental attitudes to their children to have a significant effect on them. For instance, communication about GCC at home is a stronger predictor of children's perceptions and actions regarding GCC than parents' attitudes and behaviors toward GCC (Lawson et al., 2019; Mead et al., 2012). This suggests that intrafamilial communication acts as an important mechanism underlying intergenerational transmission of environmental attitudes and behaviors via socialization.

Parental communication is also more powerful than communication with peers or teachers for predicting pro-environmental behaviors related to GCC among children (Valdez et al., 2017). Furthermore, communication at home about general environmental issues not only predicted 15-year-olds' environmental concern but also mediated the relationship between parents' and children's environmental concern (Meeusen, 2014). Likewise, Chou et al. (2023) found that children who knew about GCC and were committed to pro-environmental action also reported more frequent communication about the topic with caregivers. Especially for younger children (five-to-nine-year-olds), their parents' role in educating them about GCC made an important difference in children's understanding of GCC. However, the sample included in this study consisted of only 50 children, and the researchers did not specify the procedure they followed to determine whether the children understood GCC.

Most studies about intergenerational transmission of attitudes and behaviors concerning GCC are focused on adolescent samples and do not attend to GCC specifically, but to general environmental attitudes, behaviors, or perceptions (Chou et al., 2023; Evans et al., 2018; Grønhøj &

Thøgersen, 2012; Lawson et al., 2019; Mead et al., 2012; Meeusen, 2014; Valdez et al., 2017). To the best of our knowledge, only one study assessed children's GCC knowledge (Valdez et al., 2017), and the sample (11–14 years old) did not include young children. Hence, little is known about how the capacity to understand GCC and its perceived relevance (i.e., salience and comprehension) emerges and develops in childhood, let alone the potential influence of parenting on these processes. It is also important to note that the reviewed studies were conducted in countries from Europe, America, and Oceania. Thus, their findings may not be applicable to Spain, which is confronted with distinctive climate-related challenges. Spain's experience of prolonged heatwaves and advancing desertification (Graus et al., 2024) differs from the more abrupt and intense climate phenomena commonly observed in the United States, such as hurricanes (Lau et al., 2022). These differing environmental stressors may influence children's salience and comprehension of GCC in distinct ways. Furthermore, Spain's moderately collectivist cultural orientation (Higueras-Castillo et al., 2019) may shape how children and their families perceive and respond to GCC, potentially diverging from patterns observed in more individualistic cultures like that of the United States (Twenge & Campbell, 2018).

1.3. The current study

Our main goal was to examine young children's (5–8 years old) ability to understand GCC and how salient GCC is to them. Given that children's ability to understand abstract concepts does not fully develop until the age of 8–9 (Vigliocco et al., 2018), we hypothesized that, compared to older children, younger children would be significantly less cognizant of what GCC is and that this topic would be less salient for them. This would be reflected in lower rates of GCC salience and comprehension among younger children (Hypothesis 1). We also expected parental perception of GCC to be associated with their children's salience and comprehension of GCC (Hypothesis 2). Furthermore, we hypothesized that the relationship between parental perception of GCC and their children's salience and comprehension of GCC would be mediated by parental communication about GCC with their children (Hypothesis 3). In addition to testing these three hypotheses, we also report information on possible sociodemographic correlates (child's gender, parental education, political orientation, and family income) with children's GCC salience and comprehension. Prior findings suggest that older children, as well as female children, may understand the causes and consequences of GCC more easily than their younger or male counterparts (Ratinen, 2021). Not all studies, however, have uncovered gender differences in environmental concern (e.g., Meeusen, 2014). Greater GCC awareness, pro-environmental attitudes, and more frequent family communication about GCC have been linked to higher family socioeconomic level (Chou et al., 2023), parental educational attainment (Evans et al., 2018; Mead et al., 2012), and less conservative political views (Lawson et al., 2019), though findings on the latter have been mixed.

2. Method

2.1. Participants

An a priori power analysis was conducted using G*Power (Version 3.1.9.7; Faul et al., 2007, 2009) to determine the required sample size for logistic regression. The analysis was set with an alpha level of 0.05, a power of 0.8, an expected odds ratio of 2, and an assumed R^2 value for other predictors (excluding the variable of interest) of 0.6. Results indicated that a sample size of at least 281 participants would be needed to detect an effect. Three hundred and twelve dyads consisting of 5-8-year-old Spanish children (M = 6.54 years, 53 % female) and one of their parents participated in this study.[1] The sample of children consisted of 63 (20.2 %) 5-year-olds, 96 (30.8 %) 6-year-olds, 74 (23.7 %) 7-year-olds, and 79 (25.3 %) 8-year-olds. Most participants were from Madrid (77.2 %).

Parents' average age was 40.80 years, ranging from 24 to 55. Most were women (77.6 %) and had completed a bachelor's (27.2 %) or master's (30.1 %) degree. Some participants did not report their family income (14.4 %). Of those who did, most indicated earning an average income (48.7 %) out of the options ranging from *quite below average* to *quite above average*. Half of the sample reported their political orientation and, among those, nearly half reported being left-wing or slightly left-wing oriented (48.7 %), and the other half reported being right-wing or slightly right-wing oriented (46.1 %).

2.2. Procedure

Most children and their parents were contacted through children's schools. 56.1 % of the participants were recruited through private schools, either partly state-funded or not, while 28.8 % attended public schools (i.e., fully state-funded schools). The rest (15.1 %) were contacted through a snowball approach. Parents provided written informed consent for themselves, as well as for their children. Children provided verbal consent. The study was approved by the ethics committee at Universidad Pontificia Comillas, reference: 9/23-24.

Data collection was conducted in two separate phases. In the first one, one of the parents completed a self-report questionnaire including sociodemographic variables, parental GCC perception, and parental GCC communication with their child. Parents were asked not to tell their children in advance that the interview was about GCC.

In the second phase, children's data were collected via individual structured interviews. At the beginning of each interview, a researcher briefly explained the interview procedure to the child, not revealing that its main topic was GCC. Instead, participants were told that they were going to have a conversation about nature. Children were assured that there were no wrong answers. They were given the chance to stop the interview if they wanted, to ask questions, and to have the information repeated if needed. See a detailed description of the interview protocol in the Measures section. The average length of each interview was 20 min.

Data are available from the authors upon request to the corresponding author.

2.3. Measures

2.3.1. Parental measures

Parental Perception of GCC. Attitudes and beliefs about GCC were measured by the climate change perceptions scale (van Valkengoed et al., 2021). It has five factors that measure different types of GCC perception: 'temporal distancing' (2 items; e.g., "It will be a long time before the consequences of climate change are felt"), 'spatial distancing' (3 items, e.g., "My local area will be influenced by climate change"), 'reality' (3 items, e.g., "I believe that climate change is real"), 'causes' (3 items, e.g., "Human activities are a major cause of climate change"), and 'consequences' (3 items, e.g., "Climate change will bring about serious negative consequences"). The response format used a 7-point Likert-type scale from *1 = strongly disagree* to *7 = strongly agree*. The internal consistency of each dimension for the current sample was adequate: α temporal distancing = 0.83; α spatial distancing = 0.89; α reality = 0.88; α causes = 0.95, and α valence of consequences = 0.89.

Parental Communication about GCC. This variable was measured by using the prompt "I talk to my child about GCC" with response options

[1] 16 children from the original sample of 328 were excluded for one or more of the following reasons: 9 years old, learning disorders, and extreme shyness.

using a 5-point Likert-type scale from *1 = never* to *5 = almost always*.

2.3.2. Children's measures

Children's GCC salience and comprehension are categorical variables (yes/no). They were both assessed using the structured interview script designed by Evans and Brown (2023). Interviews started by asking children whether they knew about general environmental problems without mentioning GCC. If the child spontaneously mentioned GCC, the interviewer asked for its definition. If the participant had not brought GCC up when asked about environmental problems, the interviewer later asked the child whether they knew what GCC is, and then for a definition. In some cases, the child gave an inaccurate definition (e.g., related to normal weather changes). Only if the child did not know what GCC is or provided an inaccurate definition, the interviewer gave the following definition: "GCC means that climate, or weather, in the whole world is changing. What is happening is that the climate gets hotter and hotter. If it gets hotter, the ice in the poles melts (at this point, the interviewer made sure that the child knows what the poles are). If the ice melts, it turns into water, and the water goes down to the sea. Then, the sea level can rise." At this point, the interviewer asked for other examples of GCC consequences or phenomena. If the child did not come up with an example, the interviewer would give them examples related to drought. Next, the child was asked to define GCC based on what they understood.

Following the verbal definition, the interviewer asked the child to draw what GCC meant to them. Drawings can be particularly useful in allowing young children to express their thoughts and feelings without dependence on verbal skills (Einarsdottir et al., 2009; Milbrath & Trautner, 2008), including probing about environmental issues (Barraza, 1999). Once the child finished their drawing, the interviewer asked them to explain it.

GCC Salience. Salience was assessed at the beginning of the interview. If the child mentioned GCC when asked whether they knew about any environmental problems, we considered GCC as a salient issue to them (i.e., salience = yes). If they did not spontaneously mention GCC, we scored it as not salient to them (i.e., salience = no). Parents had been instructed not to disclose the specific objective of the study to their child prior to the interview.

GCC Comprehension (yes/no) was assessed through a decision tree designed by Evans and Brown (2023), which is available from the authors upon request. The decision was informed by what the child expressed verbally throughout the whole interview and their drawing. If the child properly defined GCC, we determined that they understood what GCC is (i.e., comprehension = yes), regardless of whether they had mentioned GCC when asked about general environmental issues. We considered a proper definition to be one that demonstrated an understanding of at least one feature of GCC (e.g., recognizing that temperatures are rising), expressed in the child's own words or related to their own environment, rather than simply parroting information mentioned by the interviewer. When a participant did not know what GCC was beforehand and the interviewer had to provide the initial definition, we determined that the participant understood GCC if they could expand on our definition by adding new concepts to the conversation or applying their knowledge of GCC to their own environment (i.e., comprehension = yes).

2.4. Statistical analysis

First, we calculated the inter-rater reliability of the children's interview decisions (Cohen's kappa). Two researchers separately assessed 98 randomly selected interviews (30 % of the full sample). When divergent judgments occurred, the two observers discussed their disagreements and then reevaluated the interview protocols.

To check Hypothesis 1, we conducted Chi-square tests to examine the relationships between children's age and their salience and comprehension of GCC. We also calculated Cramer's V. Next, we obtained descriptive statistics for the parental questionnaire. To test Hypothesis 2, binary logistic regressions were performed to identify which variables were more strongly associated with children's GCC salience and comprehension. Finally, the mediational effect of parental communication about GCC with their children on the association between parental perception of GCC and their children's salience and comprehension of GCC (Hypothesis 3) was assessed using the PROCESS macro for SPSS (Hayes, 2022).

3. Results

We evaluated the inter-rater reliability for coding 'comprehension' in the interview. The Cohen's kappa of $\kappa = 0.90$ indicated high interobserver agreement (McHugh, 2012). Twenty-four children (7.7 %) spontaneously mentioned GCC when asked about environmental issues, while 288 (92.3 %) did not. In other words, GCC was salient for 7.7 % of the children. We determined that 163 (52.2 %) children understood GCC, whereas 149 (47.8 %) did not.

A statistically significant relationship was found between children's age and salience of GCC ($\chi^2 = 17.12$, $p < .001$; $\varphi_c = 0.23$, $p < .001$). The number of children who spontaneously mention GCC increases with age, showing a steep rise between 6 and 7 years old (see Fig. 1). Similarly, a statistically significant relationship was found between age and children's comprehension of GCC ($\chi^2 = 44.01$, $p < .001$; $\varphi_c = 0.38$, $p < .001$). As shown in Fig. 2, children's understanding of GCC increases with age, with a notable rise starting at age 7. From this age onward, significantly more children grasp GCC compared to those aged 5 or 6.

Descriptive statistics of the five dimensions of the parental GCC perceptions scale are reported in Supplementary File 1, Table 1.

We conducted two binary logistic regressions to examine which variables were more strongly related to children's GCC salience and comprehension, respectively. The predictor variables included in both logistic models were children's age and gender, parental perceptions of GCC and communication about GCC at home, parental political orientation and education level, and family income. Binary logistic regressions were performed both individually for each of the predictor variables and with the variables combined in a single model, dismissing those variables that did not have a significant effect on children's GCC salience and comprehension. The interactions between children's age and each of the above-mentioned variables were also included in the models, as well as the interaction between children's gender and each of those variables.

Temporal distancing was the only dimension of parental GCC perceptions that significantly predicted GCC salience and comprehension, alongside children's age and parental communication about GCC (see

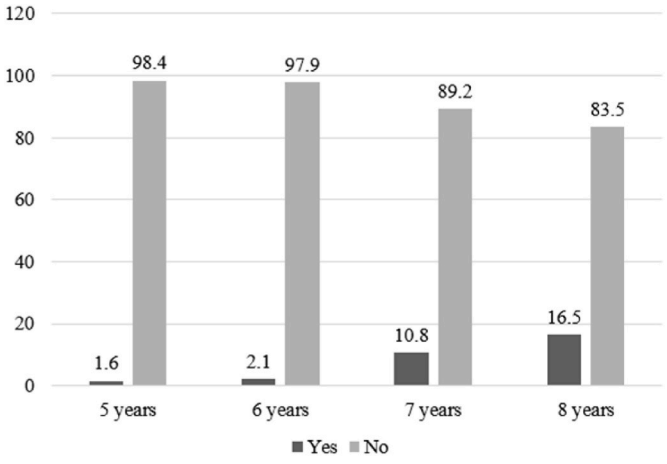

Fig. 1. Percentage of children in each age group that did ("Yes") or did not ("No") spontaneously mention global climate change.

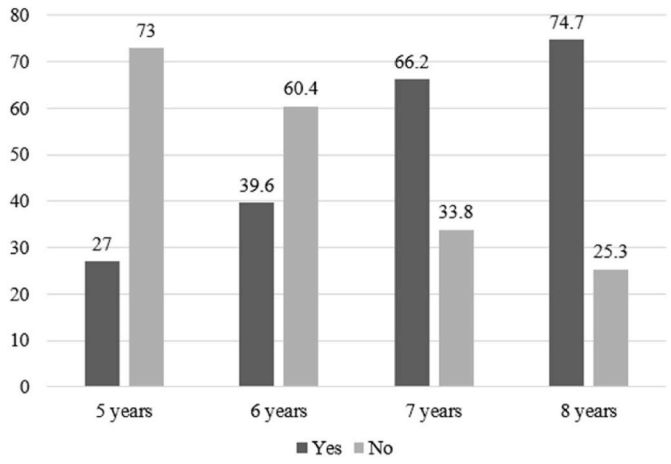

Fig. 2. Percentage of children in each age group that did ("Yes") or did not ("No") comprehend what global climate change is.

Table 1). Children's gender, family income, parental political orientation, and education level were not significantly related to GCC salience and comprehension. Non-significant results for the predictors in the binary regression analyses are summarized in Supplementary Table 2. The interaction terms were also not significantly associated with GCC salience and comprehension.

When including age and temporal distancing as predictors of GCC salience in the first regression model, the omnibus test was statistically significant ($\chi^2 = 20.94, p < .001$), suggesting that the explained variance in the model was significantly greater than the unexplained variance (Nagelkerke's $R^2 = 0.168$). The significant Wald statistic for each predictor variable (temporal distancing: $\chi^2 = 6.01$, $p = .014$; age: $\chi^2 = 11.49$, $p < .001$) indicated that they made a significant contribution to the model. The regression slope for both temporal distancing and age was positive and statistically significant.

When parental communication about GCC was included in the regression model, the omnibus test remained significant ($\chi^2 = 26.12$, $p < .001$). Nagelkerke's R^2 was 0.209. The relationship between parental communication about GCC and salience was significant ($\chi^2 = 4.66$, $p = .031$). Temporal distancing remained significantly related to salience, although the p-value of the Wald statistic almost reached non-significance ($\chi^2 = 4.15$, $p = .042$). Age was also significantly associated with salience (age: $\chi^2 = 12.01$, $p < .001$). These findings suggest that parental communication about GCC partially mediates the effect of parental perception of GCC temporal distancing on the child's GCC salience (see Table 2). Once again, the regression slopes for temporal distancing and age were positive and statistically significant. The regression slope for parental communication about GCC was also positive and statistically significant, suggesting that the probability of children spontaneously talking about GCC was higher if their parents communicated more often about GCC with them.

Moving on to the regression model where children's GCC comprehension acted as the dependent variable, our results resemble those of our previous regression model. Thus, parental perception of temporal distancing of GCC was the only dimension of parental GCC perceptions that significantly predicted whether children understood what GCC is, alongside children's age and parental communication about GCC.

When including children's age and parental temporal distancing of GCC as predictors in the regression model, the omnibus test was statistically significant ($\chi^2 = 43.59, p < .001$), as well as the Wald statistic for each predictor variable (temporal distancing: $\chi^2 = 4.98$, $p = .026$; age: $\chi^2 = 34.54$, $p < .001$). Nagelkerke's R^2 was 0.187. The results of this binary logistic regression analysis are presented in Table 1. The regression slopes for both temporal distancing and age were positive and statistically significant. This indicates that the probability of children comprehending GCC was higher if their parents perceived GCC as closer in time and if children were older.

When parental communication about GCC was included in the regression model, the omnibus test remained significant ($\chi^2 = 47.25$, $p < .001$). Nagelkerke's R^2 was 0.205. However, the relationship between temporal distancing and GCC comprehension became non-significant, while it was significant for communication and child's age (temporal distancing: $\chi^2 = 2.67$, $p = .102$; age: $\chi^2 = 33.41$, $p < .001$; communication: $\chi^2 = 5.36, p = .021$). This suggests a mediation effect (Hypothesis 3), see Table 2. The regression slope for temporal distancing was not significant, whereas the regression slope for age and parental communication about GCC was positive and statistically significant, indicating that the probability of children comprehending GCC was higher if children were older and their parents communicated more often about GCC with them.

Table 1
Binary logistic regressions for children's GCC salience and comprehension: children's age and parents' perception of GCC temporal distancing as predictors.

	Predictors	Coefficient estimate (B)	Standard error	Z-score	Wald	*p* value	OR	95 % CI	
								LL	UL
GCC Salience	Temporal distancing	0.58	0.24	2.45	6.01	0.014	1.79	1.12	2.85
	Age	0.86	0.25	3.39	11.49	<0.001	2.36	1.44	3.89
GCC Comprehension	Temporal distancing	0.21	0.09	2.23	4.98	0.026	1.23	1.03	1.48
	Age	0.74	0.13	5.88	34.54	<0.001	2.09	1.63	2.67

Note. OR = odds ratio. CI = confidence interval. LL = lower limit. UL = upper limit.

Table 2
Binary logistic regression for children's GCC salience and comprehension: children's age, parents' perception of GCC temporal distancing, and parents' communication about GCC as predictors.

	Predictors	Coefficient estimate (B)	Standard error	Z-score	Wald	*p* value	OR	95 % CI	
								LL	UL
GCC Salience	Temporal distancing	0.48	0.24	2.04	4.15	0.042	1.62	1.02	2.57
	Communication	0.63	0.29	2.16	4.66	0.031	1.88	1.06	3.33
	Age	0.92	0.26	3.47	12.01	<0.001	2.50	1.49	4.20
GCC Comprehension	Temporal distancing	0.16	0.10	1.63	2.67	0.102	1.17	0.97	1.41
	Communication	0.35	0.15	2.32	5.36	0.021	1.42	1.06	1.92
	Age	0.74	0.13	5.78	33.41	<0.001	2.09	1.63	2.68

Note. OR = odds ratio. CI = confidence interval. LL = lower limit. UL = upper limit.

Our next step was to examine if parental communication about GCC acts as a mediator in the relationship between parental perception of temporal distancing of GCC and children's GCC salience or comprehension. Given that children's age was found to be related to their GCC salience and comprehension, it was included in the mediational model as a covariate to control for its effect.

We found that parental perception of GCC temporal distancing had a significant direct and positive effect on parental communication about GCC [for salience: (b = 0.15, t (281) = 4.08, $p < .001$); for comprehension: (b = 0.15, t (281) = 4.08, $p < .001$)]. Age did not have a direct effect on parental communication about GCC [for salience: (b = 0.01, t (281) = 0.20, $p = .840$); for comprehension: (b = 0.01, t (281) = 0.20, $p = .840$)]. When communication was included in the model, the effect of temporal distancing on children's salience and comprehension became non-significant for comprehension and almost non-significant for salience [for comprehension: (b = 0.16, Z (3) = 1.63, $p = .102$); for salience: (b = 0.48, Z (3) = 2.04, $p = .042$)]. The direct effect of communication on children's salience was significant (b = 0.63, Z (3) = 2.16, $p = .031$), as well as on children's comprehension (b = 0.35, Z (3) = 2.32, $p = .021$). Additionally, we found that age was positively related to children's salience (b = 0.92, Z (3) = 3.47, $p < .001$) and comprehension (b = 0.74, Z (3) = 5.78, $p < .001$). The indirect effect of temporal distancing on children's salience was also positive and significant (b = 0.10, SE = 0.06, 95 % CI [0.01, 0.23]), as it was for comprehension (b = 0.05, SE = 0.03, 95 % CI [0.01, 0.12]). For both salience and comprehension, the 95 % confidence interval for this indirect effect did not contain 0, suggesting the existence of a mediation effect. These mediational models are represented in Figs. 3 and 4.

4. Discussion

GCC is arguably among the greatest existential threats the world has ever encountered (Cianconi et al., 2020; NASA, 2023; Perkins et al., 2012). Its consequences seriously damage the environment and, at the same time, threaten people's health (Evans, 2019; WHO, 2023). Children are notably vulnerable to the detrimental effects of GCC (Evans, 2019; Sanson et al., 2019), and they will need to cope over the long run with the consequences of contemporary actions to combat GCC. Thus, a deeper understanding of children's perception of this phenomenon is needed, especially at younger ages (Grønhøj & Thøgersen, 2012; Lawson et al., 2019; Mead et al., 2012; Meeusen, 2014; Valdez et al., 2017). The growing body of work on children and GCC shows that children's knowledge about GCC is often inaccurate and encompasses some misconceptions regarding its causes, consequences, and solutions (Ratinen, 2021; Shepardson et al., 2011; Teixeira et al., 2024). There is also little research on the effect of age on the ability to understand such a complex concept (Teixeira et al., 2024). To fill in this gap in the literature, this study examined 5-to-8-year-olds' salience and comprehension of GCC and explored its association with parents' perception and communication about GCC.

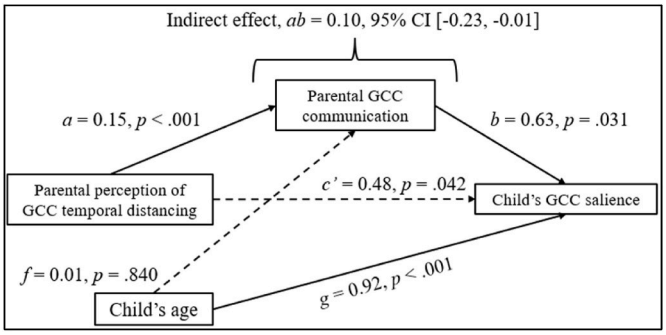

Fig. 3. Predictive model of children's GCC salience.

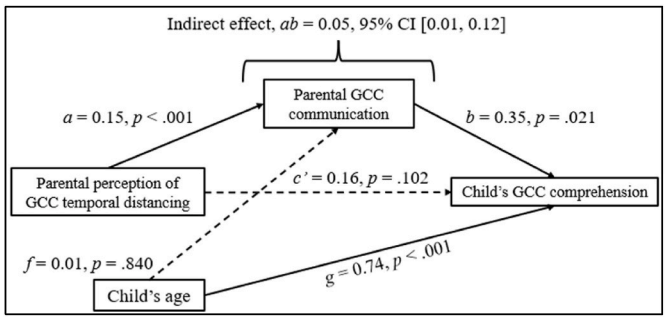

Fig. 4. Predictive model of children's GCC comprehension.

4.1. Age, GCC salience and comprehension

We found that, when asked about environmental problems in general, very few children spontaneously mentioned GCC (7.7 %). Low GCC salience is to be expected from a sample of such young children, given initial findings that comprehension of complex phenomena is developed around ages 8–9 (Vigliocco et al., 2018). However, we determined that half of the sample was able to understand the concept of GCC, even though it was not uppermost in their minds when asked about environmental problems. Some of them already knew about GCC before the interview, while others expanded on a definition provided by the interviewer. While this is the first study on GCC comprehension conducted in such a young sample of children, it is noteworthy that the percentage of children who comprehend GCC seems to be similar to that found in the study by Ratinen (2021), which involved a much older sample (10- to 15-year-olds). A possible explanation may be that Ratinen's sample used a more stringent assessment for determining participants' understanding of GCC: they had to complete a questionnaire about GCC causes, mitigation, and adaptation measures.

In line with our first hypothesis (Hypothesis 1), we found that children's comprehension and salience of GCC significantly increased with age (see Figs. 1 and 2). By age 7, nearly every child in our sample had at least a rudimentary understanding of what GCC is (66.2 % of 7-year-olds), and for some of them, it was also a salient problem. This is the approximate age when children demonstrate the acquisition of logical thinking (e.g., the ability to establish relationships between physical elements, to classify them or to understand the independence between some of their dimensions). Our findings also converge with research showing that older children acquire a more nuanced understanding of climate change and become more concerned about the environment as they grow older (Teixeira et al., 2024).

4.2. Effects of parental GCC perceptions

Age is not the only factor related to children's ability to understand GCC and to their perception of its importance. Some researchers suggest that children's GCC knowledge and pro-environmental attitudes might develop through intergenerational transmission, with parents acting as primary socialization agents (Matthies & Wallis, 2015). Parents' pro-environmental behavior predicts their children's pro-environmental attitudes and behaviors towards GCC, although parents' attitudes do not seem to be associated with their children's pro-environmentalism (Hahn, 2021; Lawson et al., 2019). In the present sample, the average parental GCC perception scores were reasonably high, indicating awareness of this problem. In line with Hypothesis 2, parental perception of GCC was positively associated with both children's salience and comprehension of GCC. Interestingly, however, not all kinds of GCC perceptions appear to be related to children's understanding and salience of GCC: only parental perception of temporal distancing of GCC was associated with children's GCC salience and comprehension. As with other day-to-day family topics and activities (Wingard, 2007), it

seems that in parent-child interactions, parents prioritize topics and activities they perceive as more pressing in terms of time. Other factors (e.g., who is responsible for GCC) do not appear to be related to parental decisions to talk about this phenomenon with their children.

4.3. Parental communication as a mediator

Communication about GCC at home could be associated with what their children understand and feel about GCC (Lawson et al., 2019; Mead et al., 2012). We found support for Hypothesis 3, which predicted the relationship between parental GCC perception and children's salience and comprehension of GCC to be mediated by parental communication about GCC. Our data adequately fit a mediation model where parental perception of GCC is associated with parental communication about GCC with their children which, in turn, had a positive effect on children's ability to understand GCC and its salience (see Figs. 3 and 4). All the above-mentioned results are in line with prior research with 15-years-old children that also revealed that communication about environmental problems mediated the relations between parents' pro-environmental attitudes and behaviors and those of their children (Meeusen, 2014). Additionally, other studies have found communication about GCC to be a relevant mechanism through which parents' perceptions of GCC relate to their children's comprehension and feelings regarding GCC, along with parents' pro-environmental behaviors (Collado & Evans, 2023; Lawson et al., 2019; Mead et al., 2012).

4.4. Sociodemographic factors

Although secondary to our primary objectives in this study, we also explored the relationships among young children's salience and comprehension of GCC and various sociodemographic variables that have previously been examined among older children. Overall, none of the sociodemographic variables we considered were related to children's GCC salience and comprehension. Regarding children's gender, prior work has shown mixed findings. Meeusen (2014) found no gender differences in environmental concern (a concept closely related to salience), which aligns with our own results. However, our findings contradict Teixeira and others' (2024) results, which showed that girls aged 10–13 had a more accurate understanding of most aspects of GCC. Similarly, Ratinen (2021) found that female children more frequently understood both the causes and consequences of GCC compared to boys ages 10 to 15.

The socioeconomic level was not related to children's GCC salience or comprehension in our study, which contrasts with Chou et al.'s (2023) findings with children aged 5 to 18. In their study, greater awareness of GCC and pro-environmental attitudes were linked to a higher family socioeconomic level. Similarly, in line with Whitmarsh's (2011) results, parental political orientation was also unrelated to children's environmental perception, which contradicts Lawson and others' (2019) findings. Additionally, parental educational level was not related to children's salience and understanding of GCC in our study. This result contradicts Evans et al.'s (2018) findings showing that greater awareness of GCC and pro-environmental attitudes were linked to maternal educational attainment. However, it is worth noting that these authors used longitudinal data and focused on a different age range (6-to-18-year-olds), which allowed them to more sensitively detect intra-child differences that might only be visible over time. These findings underscore the need for further longitudinal research into the relationship between sociodemographic variables and GCC salience and comprehension throughout the lifespan.

4.5. Implications for environmental education

Our findings have potential implications for young children's environmental education (EE), both at home and in school. First, we demonstrate that most 5-year-olds do not understand GCC, but by age 7, two-thirds of the children have acquired at least a rudimentary understanding of GCC. Some children exhibited understanding even earlier, though this does not necessarily mean they perceive GCC as a relevant environmental problem. In fact, 5-to-8-year-olds rarely mention GCC when asked about general environmental issues, suggesting it is not so salient for this age group. Therefore, when designing EE programs aimed at children younger than 7, practitioners may consider focusing on aspects of GCC that children can directly experience, rather than presenting it as an abstract issue. Children under seven would likely benefit more from tangible, experiential descriptions than from abstract representations. Additionally, communication with children about GCC may benefit from more specific terminology because young children tend to interpret the words used literally (e.g., thinking that 'climate change' means "normal weather changes"). For example, in Lee and Barnett's study (2020), some children aged 10–12 asked: "What is the difference between weather and climate change?". Even though global warming only refers to one of the aspects of GCC (i.e., the rise of temperatures), it might be easier for children to grasp some of the nuances of GCC when using this specific term. Further qualitative research may help discern what terminology is more appropriate when talking to young children about GCC.

Our results highlight the importance of considering social interactions surrounding the development of children's ability to understand GCC. Thus, parents should also be a key target of EE programs. Since GCC temporal distancing was the only dimension of the GCC parental perceptions scale associated with their children's GCC salience and comprehension, EE programs should emphasize the urgency of GCC. Additionally, EE interventions for parents could focus on the importance of discussing GCC with their children. To facilitate parental interventions, it may be helpful to provide parents with adequate communication tools. Such materials may help parents overcome the fear that their children might become overwhelmed by GCC's severity and support more consistent, widespread communication.

4.6. Limitations and future research

The results obtained in this study should be considered in light of some limitations. First, it is difficult to measure the age at which children begin to comprehend complex phenomena such as GCC. As noted, many adults themselves have an inaccurate or only partial understanding of GCC. In this study, we attempted to identify the age at which children demonstrate comprehension of GCC by using several methodological techniques. Given potential semantic limitations, we relied on both verbal and nonverbal responses, such as drawings. We also began the interview with a series of open-ended questions administered in a standardized manner, coupled with careful use of prescribed probes, following extensive training of interviewers. As indicated, we achieved excellent interrater reliability for the decision of whether a child understood GCC. However, it is reasonable to question the criteria used to determine comprehension.

Given the young age of our sample (5–8 years), we consciously set a low threshold for comprehension. That is, while children who described some aspects of GCC correctly without any assistance were scored as demonstrating understanding, additional responses also could lead to our assessment of some understanding of GCC. We did this by providing a standardized definition of GCC, using the same words and examples. Then, we asked follow-up questions to assess whether each child could provide additional examples or restate in their own words what GCC is. Responses that merely parroted the definition or closely mimicked its content were not considered evidence of comprehension.

Second, the research design is cross-sectional, so we cannot establish causality. From a developmental perspective, future studies should collect longitudinal data to better observe the influence of parental GCC perception and communication on the same children's GCC salience and comprehension over time (see, for example, Evans et al., 2018). The mediational findings on parental temporal distancing and

communication about GCC salience and comprehension are suggestive but not definitive since mediation cannot be proven with cross-sectional data. Furthermore, although age appears to be a main contributor to understanding GCC in the present study, there are many other factors that might be associated with children's GCC comprehension (e.g., participation in environmental education programs; previous experience of GCC events). As in any developmental study, we have tried to consider some of those factors in our study (e.g., parental communication about GCC), but we cannot possibly account for all of them in a single study. Nonetheless, given that this is the first study on GCC salience and comprehension among children ages 5–8, the data are also valuable for suggesting future research directions. Experimental studies implementing different possible influential factors (e.g., other types of parental influences, such as parents' emotions about GCC) could yield interesting insights and help overcome these limitations.

Third, parental data were collected using self-report questionnaires, so their answers could be subject to biases (e.g., recall or social desirability). Future studies could employ more objective or indirect measures, such as direct observation.

Fourth, all the participants lived in Spain, and most of the children were white, lived in urban areas, and attended private or partly state-funded schools. The parental sample was mostly women, and a majority had reached a high education level (bachelor's and master's degrees). Given the evidence that better-educated parents talk with their children more (Mead et al., 2012), the highly educated sample here may underestimate how parental communication contributes to young children's knowledge of GCC. Participants were recruited using a non-probability, convenience sampling methodology, and participation was voluntary. It is possible that most of the parents who decided to collaborate already had some modicum of GCC awareness. In fact, their average scores in the GCC perceptions scale and in each of its subscales were reasonably high, indicating awareness of this problem. However, the minimum score obtained in each of the climate change perceptions subscales indicates that people with low environmental awareness also took part in this study. Although the age groups and questions examined herein are new, our sample is not representative. Moreover, we cannot assume that our findings are generalizable to geographic regions outside of Spain, as this country faces specific climate-related challenges (Graus et al., 2024) and is characterized by a more collectivist cultural orientation compared to countries such as the United States (Higueras-Castillo et al., 2019; Twenge & Campbell, 2018). These contextual factors may influence children's perception and salience of GCC, as well as how parental variables shape their understanding. Thus, we suggest replicating this research with a more heterogeneous sample recruited from different geographic areas.

Regarding other future lines of research, it would be interesting to assess the influence that children exert on their parents regarding GCC. The intergenerational influence that occurs within the socialization process is bidirectional. Children can also influence their parents' attitudes and behaviors (Bandura, 1989), although only a few studies have assessed this type of influence regarding pro-environmental behavior (Lawson et al., 2018; Singh et al., 2020; Tian et al., 2023). Whether children's GCC salience and comprehension influence parental perception of GCC remains for future studies.

4.7. Conclusions

GCC is an increasingly pressing problem, with rapidly accelerating, negative consequences for the Earth and human beings. Children are especially vulnerable to the effects of GCC (Evans, 2019; Sanson et al., 2019) and, at the same time, they are critical agents to deal with GCC in the future (Vergunst & Berry, 2022). Thus, it is crucial to better understand children's perceptions of GCC and how these are formed. Our results show that children's salience and comprehension of GCC increase significantly from the age of 7 onwards. We have also shown that parent-child communication may play a relevant role in their children's understanding of GCC and the importance they place on it. Parents who perceive GCC as a current issue communicate more about it with their children, which, in turn, makes GCC more salient for children and leads to understanding GCC. Given our results, parental perception of GCC and children's age should be considered when raising awareness about GCC. Children's gender and parents' political orientation, education level, or family income, at least within the present sample, do not appear to be related to children's understanding of GCC and how important it is for them. These findings highlight the importance of fostering both children's and their parents' environmental awareness within the environmental education domain.

CRediT authorship contribution statement

Marta Carballo-Losada: Writing – original draft, Visualization, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Silvia Collado:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization. **Rocío Rodríguez-Rey:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization. **Abigail Brown:** Writing – review & editing, Validation, Methodology. **Gary W. Evans:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of interest

Declarations of interest: none.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2025.102656.

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