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Emotional appraisal of climate change in young Andalusians: structural equation modelling and multigroup analysis

Evaluación emocional sobre el cambio climático en jóvenes andaluces: análisis de ecuaciones estructurales y multigrupo

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Abstract:

Climate change is one of the most urgent environmental and societal challenges of our time. Since the mid-20th century, psychoeducational research has shown correlations between emotional processes and action-oriented decision-making. The *appraisal theory of emotions* posits that emotions arise from processes of appraisal, both unconscious and conscious, shaped by numerous factors. A thorough examination of the influence of these factors, and of how they modulate emotional appraisal in the context of the climate emergency, is a crucial step towards guiding educational interventions towards more holistic pedagogies focused on climate action.

In this context, the present study aims to develop an exploratory structural model to examine how frequency of information consultation and perceptions of responsibility and risk influence emotional appraisals of climate change. To this end, the structural equation modelling was applied to a sample of young individuals from eight provinces in Andalusia, Spain (n = 1,050). A multigroup moderation analysis was conducted to explore whether differences in academic year between subjects influence these relationships.

The fit of the proposed model is favourable, explaining almost half of the variance in negative emotions and nearly a quarter of the variance in positive emotions. The results highlight significant causal patterns, with risk perceptions showing large and particularly relevant regression weights on negative emotions towards climate change. We also examined the significant and incremental influence of social networks (both online and offline) and the perceptions of externalised responsibility for the causes of climate change, especially as students advance through the education system. These are all crucial aspects for educators to consider.

Keywords: climate change, structural equation modelling, young people, emotions, emotional processing and appraisal, information sources, risk perceptions and responsibility

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Resumen:

El cambio climático es uno de los problemas ecosociales más urgentes a los que debe enfrentar la humanidad. La investigación psicoeducativa, desde mediados del siglo XX, ha identificado conexiones entre los procesos emocionales y la toma de decisiones orientadas a la acción. La *Teoría de la evaluación emocional* sostiene que las emociones son el resultado de un proceso de valoración (inconsciente y/o consciente) que es condicionado por numerosos factores. Explorar en profundidad la influencia de algunos de estos factores, así como la modulación que ejercen en la evaluación emocional ante la emergencia climática, se considera fundamental para orientar la intervención educativa hacia pedagogías más holísticas y enfocadas a la acción climática.

En este contexto, la presente investigación tiene como objetivo elaborar un modelo estructural exploratorio que permita entender cómo influyen la frecuencia de consulta de información y las percepciones de responsabilidad y riesgo en la evaluación emocional sobre el cambio climático. Para ello, se utiliza la técnica de análisis de ecuaciones estructurales en una muestra de jóvenes españoles de las 8 provincias de Andalucía (n=1.050). Se explora cómo la diferencia de curso educativo entre los sujetos puede influir en estas relaciones, mediante un análisis multigrupo de moderación.

El nivel de ajuste del modelo es favorable, logrando además explicar casi la mitad de la varianza de las emociones negativas, así como cerca de un cuarto de las positivas. Los resultados muestran la presencia de patrones causales significativos, siendo especialmente relevante el gran peso de regresión que tienen las percepciones de riesgo sobre las emociones negativas respecto al cambio climático. Asimismo, analizamos la influencia significativa e incremental que ejercen las redes sociales (tanto *online* como físicas) y las percepciones de externalización de la responsabilidad causal del cambio climático, especialmente a medida que los estudiantes avanzan en el sistema educativo; todos ellos son aspectos cruciales que deben tener en cuenta los educadores.

Palabras clave: Cambio climático, análisis de ecuaciones estructurales, jóvenes, emociones, procesamiento y evaluación emocional, fuentes de información, percepciones de riesgo y responsabilidad.

1. Introduction

The present article aims to explore causal influences in the emotional response to climate change expressed by young people. We used structural equation modelling (SEM) as an exploratory strategy to identify significant relationships between variables that scientific literature has linked to changes in patterns of emotional elicitation. Specifically, this study seeks to clarify how the following variables shape the process of emotional appraisal: 1) frequency of consulting different media sources for information on climate change; 2) perceived risk of its consequences, both at the individual level and for Andalusia; 3) perceived responsibility for the cause of climate change, attributed both to oneself and to Andalusia. In addition, the influence of the *year group* demographic variable is explored through moderation analysis.

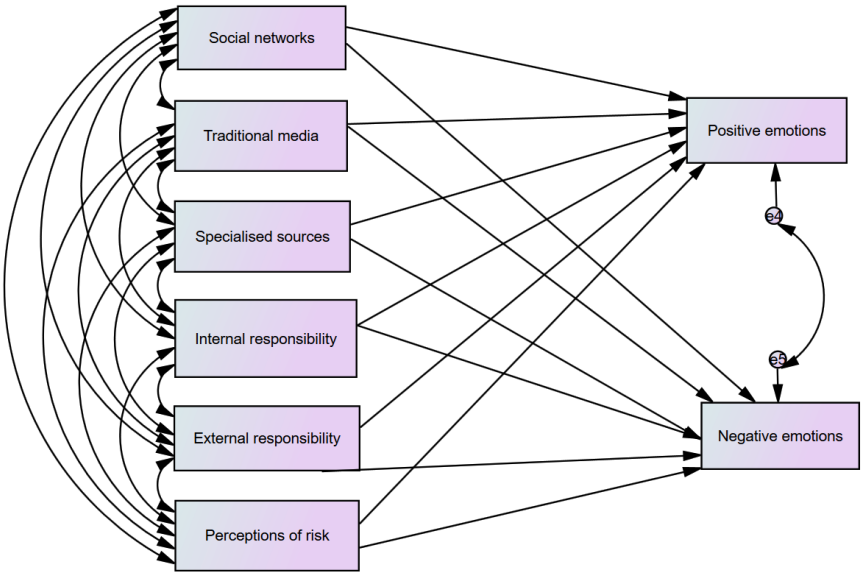
These variables are shown in the *theoretical model* proposed in Figure 1, which we will try to test using an exploratory SEM that permits in-depth consideration of how and to what extent the frequency of media source consultation, together with perceived responsibility and risk, influence the process of *emotional appraisal* regarding climate change. These study aims are articulated in the following research objectives:

Objective 1. To analyse the fit of the *structural model* to the overall sample and determine the proportion of emotional variance it explains.

Objective 2. To interpret the significance, strength and direction of the associations between the exogenous variables of the *structural model* and the endogenous variables of *positive* and *negative emotions* in the overall sample.

Objective 3. To examine potential differences in the structural relationships of the *structural model* arising from the moderating effect of the *year group* variable.

FIGURE 1. Theoretical Model



Source: Prepared by the authors

2. Theoretical framework and state of the art

Over the past decade, there has been growing interest in the study of emotions in the context of the climate emergency. Among the emerging lines of research in this field, particular attention has been paid to studies examining how these complex and multidimensional socio-psychological processes differ across groups, and how they correlate with factors such as interest, motivation to act and intention to change habits in response to the climate emergency.

In a survey of 10,000 young people (aged 16-25) across 10 countries, Hickman *et al.* (2021) concluded that: 1) respondents frequently report feeling negative emotions such as eco-anxiety, sadness, fear, anger and hopelessness, which affected their daily life; 2) these negative emotions were associated with critical perceptions of government actions to address the climate crisis; 3) the elicitation of negative emotions in relation to climate change is not exclusively limited to the countries most affected by this phenomenon; and 4) it is vital to validate young people's emotions and urge governments to take effective action in the face of the climate crisis to safeguard the emotional and mental well-being of these generations. In the opinion study by Ogunbode *et al.* (2022), the authors explored correlations between eco-anxiety, well-being and pro-environmental action in 32 countries based on a total sample of 12,246 subjects. The inverse relationship between psychological well-being and eco-anxiety in 31 countries, as well as the significant association with pro-environmental behaviours (24 countries) and climate activism (12 countries) stand out among the most significant findings.

With regard to the range of emotions elicited by climate change, it is important to highlight the work of Pihkala (2022). In this study, the author presents a semi-systematic narrative review (n = 14) of empirical studies, including observational or self-report surveys, that address at least five distinct climate emotions. Its main contribution is an emotional taxonomy of climate change, illustrating connections between climate emotions and resilience, climate action, psychological well-being and health. Pihkala also concludes that this field of research is still emerging, and notes a lack of research into the variety of emotions associated with climate change.

Ojala's (2022) review shifts the focus from negative emotions, which have traditionally received greater attention in the context of climate change, to positive emotions elicited when individuals perceive the precursor object or situation as favourable to their well-being, survival or goals (Borsch, 2021). Ojala note that recent research in this area, although limited, examines the relationship between hope, motivation, and participation in climate action. The following conclusions of the study are particularly noteworthy: 1) interventions should focus on spreading messages that promote and encourage individual and collective action in response to climate change, rather than simple optimistic messages; and 2) it is necessary to distinguish between optimism, understood as a belief that everything will turn out well without the need for action, and hope, understood as the perception that improvement is possible when facing a negative situation. In the latter case, it is important to identify the *emotional appraisal* process, as it will shape a form of hope that may hinder or drive climate action, which Ojala terms *critical hope*. According to the *appraisal theory of emotions*, *emotional appraisal* is an unconscious and/or conscious process based on prior experiences, values, perceptions and beliefs, among other factors, which influences the intensity and positive or negative valence of the resulting emotional response (Moors *et al.*, 2013).

In the study of pro-environmental and climate behaviours, the classic work by Kollmuss and Agyeman (2002) stands out as one of the most influential in bibliometric terms. These authors reviewed leading theories and models that aimed to explain the factors influencing decision making, as well as the possible barriers that hinder its implementation. Their principal contribution is a new multivariate model, supported by the previous models, which identified three major factors that shape pro-environmental behaviours: 1) demographic factors: gender, age, educational level, etc.; 2) external factors: institutional, economic, social and cultural influences; and 3) internal factors: motivation, knowledge, values, emotions, individual responsibility, among others. Within the internal factors block, particularly those linked to emotions and emotional reaction, they observed that negative emotions elicited by environmental problems (e.g., fear, sadness, anger) may not serve as causal predictors of pro-environmental behaviours. Rather, it is the subjects' perceived sense of control in the face of the situation that elicits these feelings. Accordingly, individuals who feel little control over the evolution of an eco-social problem such as climate change, combined with strong negative emotions, are more likely to develop behaviours of avoidance, apathy and delegation.

Building on previous literature and responding to the demand for research in this field, our study seeks to identify how young people appraise climate change emotionally, and to determine which predictors shape their emotional elicitation and decision making in the face of the climate crisis.

3. Methodology

3.1. Study instrument and sample

The present research employs a survey design using a third-generation *ad hoc* questionnaire that was reviewed by national and international experts and has been applied in previous research by the RESCLIMA Project (González-Muñoz *et al.*, 2024; García-Vinuesa *et al*., 2024; Meira *et al*., 2022).

The purpose of this quantitative questionnaire, which gathers respondents' opinions, is to characterise social profiles in relation to the climate emergency and provide an empirical basis to guide strategic educational and political interventions aimed at enhancing climate literacy and fostering young people's commitment to action. Through a multivariate orientation, the questionnaire enables integrated analysis of seven thematic blocks (González-Muñoz *et al*., 2024). The present study focuses on the *Information Sources* and *Emotions* blocks and, partially, the *Beliefs and Perceptions* and *Socio-educational Variables* blocks.

Information Sources were assessed through a general instruction inviting participants to indicate how often they used different media to obtain information about climate change, on a scale from 1 (rarely) to 3 (often). An exploratory factor analysis (EFA) identified three factors: 1) *traditional media*, including television, popular magazines, and newspapers; 2) *social networks*, comprising online networks (TikTok, Instagram, YouTube, etc.) as well as offline networks (friends, family, etc.); and 3) *specialised sources*, which include workshops, talks or activities with teachers, NGOs or environmental groups.

Perceptions of responsibility for the causes of climate change were explored through two items: *external responsibility* ('indicate from 1 [minimum] to 10 [maximum] the responsibility of Andalusia for the causes of climate change'), and its equivalent for personal responsibility, or *internal responsibility*. Risk perceptions were measured using a similar structure and scale, asking respondents to assess how they thought climate change could affect Andalusia and their own lives. The focus on individuals and their autonomous region was chosen to minimise possible divergences in responses, particularly those linked to emotional distancing, and to maintain a focus that was more local and context-specific than, for example, a nationwide scale.

First, the possibility of grouping the responsibility and risk items into two latent variables was examined. The perceived risk items showed a significant moderate-to-strong correlation (Pearson = 0.53, Spearman = 0.52, p = 0.00), as well as satisfactory R^2 coefficients in the confirmatory factor analysis (CFA), which justified grouping them into a single latent factor: *perceived risk*. By contrast, and despite having prioritised a local focus, the responsibility items displayed only a significant weak-to-moderate correlation (Pearson = 0.35, Spearman = 0.34, p = 0.00) along with R^2 values below the established threshold (≥ 0.50), indicating insufficient strength to justify grouping them into a single latent construct.

To assess *emotions*, respondents were given the following instruction: 'Assess from 1 (not at all) to 10 (a lot) how strongly you experience the following emotions and feelings when you think about climate change.' A self-report technique was used, without providing specific contexts or examples that might influence responses. An exploratory factor analysis (EFA; González-Muñoz *et al*., 2024), confirmed a polarisation of items into two factors, consistent with the dimensional model of emotions based on valence: 1) *positive emotions*, comprising optimism and hope; and 2) *negative emotions*, comprising worry, fear, anger, indignation, sadness and impotence. The eight climate emotions included in the questionnaire were selected on the basis of their frequency in responses to an open-ended item in the first pilot study.

The final study sample comprised 1,050 young people from the eight provinces of Andalusia, Spain. Voluntary stratified sampling was used, involving 26 secondary schools (68.4% public and 31.6% state-supported private). Half of the participants identified as female, and half as male. Regarding *year group* and *age*, 56.2% of the participants were in Year 1 of Compulsory Secondary Education (ESO, equivalent to Grade 7 in the K-12 education system, aged 12-13 years), while the remaining 42.8% were in Year 4 of ESO (Grade 10 K-12, aged 15-16 years).

The research was conducted in accordance with the principles of the Helsinki Declaration. Participants were provided with an information sheet and were asked to give fully informed consent, and the principles of voluntary participation and anonymity were complied with

at all times. The project was approved by the Ethics in Human Research Committee of the Universidad de Granada (reference 3252/CEIH/2023).

3.2. Data analysis

The *theoretical model* proposed in this study was developed on the basis of an extensive literature review, together with the results and conclusions from the authors' exploratory, descriptive and inferential factor analyses (González-Muñoz *et al.*, 2024). The IBM SPSS v.28 package and IBM SPSS AMOS v.24 statistics programs were used for the analyses.

As a necessary preliminary step for SEM, a CFA was performed with the data and variables included in the *measurement model*. This CFA assessed three criteria: 1) *reliability*, with all of the latent variables achieving the required coefficients for *internal reliability* (Cronbach's alpha and McDonald's omega ≥ 0.70), *composite reliability* (≥ 0.60), and *average variance extracted* (≥ 0.50), indicating satisfactory reliability (Cronbach, 1951; Dash & Paul, 2021; McDonald, 1970); 2) *construct validity*, with the necessary coefficients achieved for *convergent validity* (factor loadings ≥ 0.60, with $p < 0.05$; $R2 \geq 0.50$), and *discriminant validity*, assessed using the Fornell–Larcker test, confirming validity (Fornell & Larcker, 1981; Zainudin, 2015); and 3) *goodness of fit*, evaluated following Hu and Bentler (1999) and Schreiber *et al.* (2006), with both *absolute fit* and *comparative fit* tests exceeding the required thresholds, indicating a good model fit (Table 1).

Table 1. Goodness of Fit of the Measurement Model

	Index name	Value
Absolute fit	Chi-squared (CMIN)	X2=161.62; DF=64; p=0.00
	Chi-squared/degrees of freedom (CMIN/DF)	2.53
	Goodness of fit index (GFI)	0.98
	Adjusted goodness of fit index (AGFI)	0.97
	Root mean square error of approximation (RMSEA)	0.04
	Standardised root mean squared residuals (SRMR)	0.02
Comparative fit	Tucker–Lewis index (TLI)	0.97
	Incremental fit index (IFI)	0.98
	Normed fit index (NFI)	0.97
	Comparative fit index (CFI)	0.98

Source: Prepared by the authors

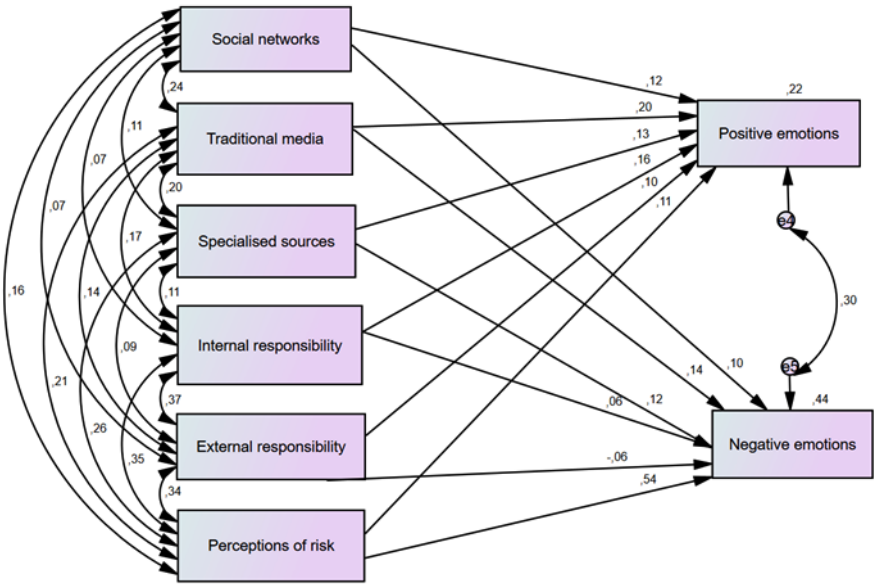
After testing the *reliability*, *construct validity* and *goodness of fit* of the *measurement model*, a *structural model* was developed with the overall sample (*General-StrMod)*. Using SEM, this model analyses both the proportion of emotional variance explained and the structural relationships among the variables. A multigroup analysis was also conducted to test the possible moderating effect of the *year group* variable. Exploring this variable was considered vital, rather than others such as ideology or prior experiences, for two main reasons: 1) homogeneity in the educational context, which allowed greater control of sample distribution between the two groups than more volatile or inconsistent variables; and 2) its interrelation with age, which enables simultaneous analysis of educational aspects and factors linked to cognitive, social, and emotional development. Nevertheless, the relevance of other variables is recognised for future lines of research within the framework the team is currently developing.

4. Results

4.1. Structural equation modelling

To represent the *General-StrMod* (Figure 2), an imputed version of the data was used. The model has six exogenous variables and two endogenous variables. The results of the *absolute* and *comparative fit* tests assessing the *goodness of fit* of the *General-StrMod* are identical to those obtained for the *measurement model* (Table 1).

Figure 2. General-StrMod: Standardised Regressions and Mean Explained Variance



Source: Prepared by the authors

Table 2 presents the results of the tests of association between the variables in the *General-StrMod*. In particular, it shows the regression weights and standardised regression weights, which reflect the direct effects of the exogenous variables on the endogenous ones in the model.

TABLE 2. Tests for Association Between Variables: General-StrMod.

Association of variables	Regression weight				Standardised regression weight
	Estimate(B)	SE	CR	*p*	Estimate(β)
PosEm←SocNet	0.12	0.03	4.44	***	0.12
PosEm←TradMed	0.24	0.03	7.33	***	0.20
PosEm←SpeSour	0.15	0.03	4.89	***	0.13
PosEm←InRe	0.04	0.01	5.34	***	0.16
PosEm←ExRe	0.03	0.01	3.31	***	0.10
PosEm←RiskPer	0.06	0.02	3.77	***	0.11
NegEm←SocNet	0.12	0.03	4.44	***	0.10
NegEm←TradMed	0.22	0.04	6.08	***	0.14
NegEm←SpeSour	0.17	0.03	4.98	***	0.12
NegEm←InRe	0.02	0.01	2.44	0.02*	0.06
NegEm←ExRe	–0.03	0.01	–2.46	0.01**	–0.06
NegEm←RiskPer	0.40	0.02	21.54	***	0.54

Note: PosEm= Positive Emotions; SocNet = Social Networks; TradMed = Traditional Media; SpeSour = Specialised Sources; ExRe = External Responsibility; InRe = Internal Responsibility; RiskPer = Risk Perceptions; NegEm = Negative Emotions; SE = Standard Error; CR = Critical Ratio; * = $p \leq 0.05$; ** = $p \leq 0.01$; *** = $p \leq 0.00$

Source: Prepared by the authors

4.2. Multigroup analysis of the year group variable

To determine whether the *General-StrMod* can be compared between the groups defined by the *year group* variable (Year 1 ESO vs Year 4 ESO), an analysis was conducted (Table 3) in which progressive restrictions were imposed on the factor loadings (model 1), structural relationships (model 2) and residual errors (model 3), with model fit assessed in each phase. The results indicate that the model is invariant across the groups defined by the *year group* variable, allowing valid comparisons of structural relationships that can be attributed to its possible moderating influence (Chen, 2007).

TABLE 3. Multigroup Invariance Matrix

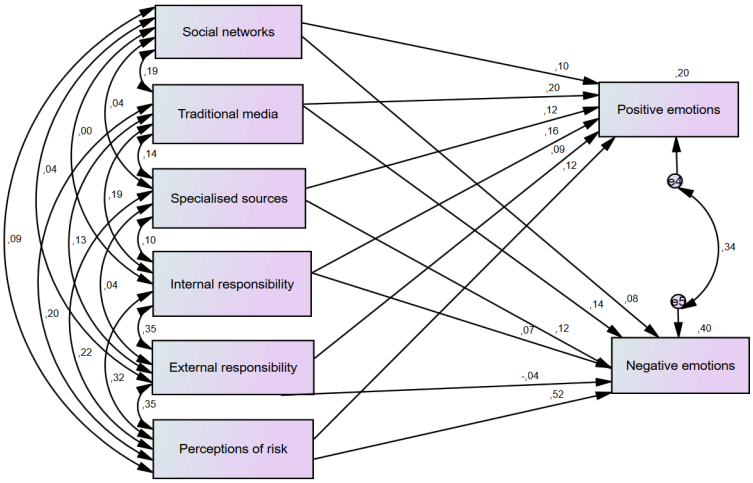
	CFI		ΔCFI
Model 0. Free from configural invariance	1		
Model 1. Metric invariance (M0 vs M1)	M0 1	M1 1	0.00
Model 2. Structural invariance (M0 vs M2)	M0 1	M2 0.99	0.01
Model 3. Residual invariance (M2 vs M3)	M2 0.99	M3 0.98	0.01

Source: Prepared by the authors

A chi-squared difference test was conducted to assess possible significant differences between the structural regressions of the *General-StrMod* owing to the moderating effect of the *year group* variable. This test compared the unrestricted model (base model) with a model that imposes invariance restrictions on the *year group* variable. The comparison (ΔCMIN = 25.34; ΔDF = 21; p = 0.04) indicated a significant moderating effect of *year group* on the model's structural relationships, warranting further exploration.

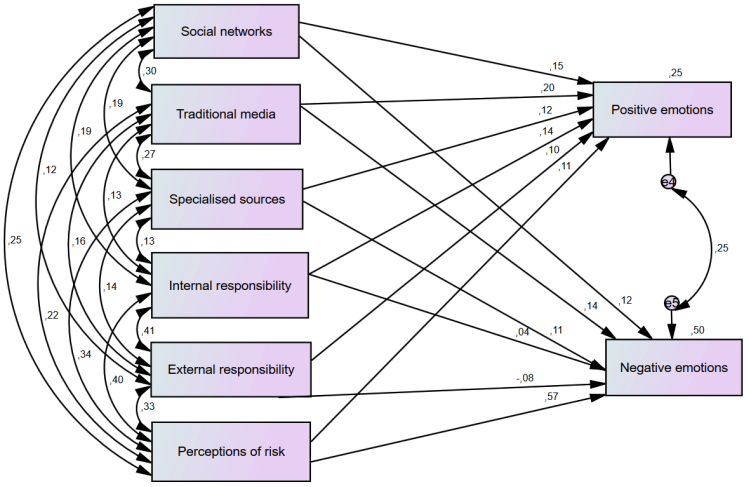
Twelve chi-squared difference tests were then carried out, each assessing one of the structural relationships proposed in the model. Statistically significant differences were identified for the following relationships: *positive emotions* ← *social networks* (ΔCMIN = 4.11; ΔDF = 3; p = < 0.05), *negative emotions* ← *social networks* (ΔCMIN = 4.58; ΔDF = 2; p = 0.03), and *negative emotions* ← *external responsibility* (ΔCMIN = 4.95; ΔDF = 2; p = 0.02). Following these analyses, the *structural model* for Year 1 ESO *(Year 1 ESO-StrMod)* and the *structural model* for Year 4 ESO *(Year 4 ESO-StrMod)* were represented in AMOS, with their imputed versions shown in Figure 3 and Figure 4 respectively.

FIGURE 3. Year 1 ESO-StrMod



Source: Prepared by the authors

FIGURE 4. Year 4 ESO-StrMod



Source: Prepared by the authors

Table 4 presents the descriptive statistics and inferential analyses for both groups on the variables included in the model.

Table 4. Descriptive and Inferential Results by Year Group

	Year 1 ESO		Year 4 ESO		Inferential test	
	$\overline{x}$	SD	$\overline{x}$	SD	ANOVA *(p)*	Kruskal-Wallis *(p)*
Social networks	2.22	0.74	2.19	0.72	0.49	0.43
Traditional media	1.81	0.63	1.79	0.64	0.51	0.48
Specialised sources	2.03	0.67	1.76	0.67	***	***
Internal responsibility	5.91	2.84	5.87	2.47	0.53	0.47
External responsibility	5.86	2.34	5.68	2.01	0.16	0.15
Risk perceptions	7.22	2.10	7.19	2.08	0.79	0.77
Positive emotions	6.40	1.76	5.92	1.81	***	***
Negative emotions	6.39	2.12	6.45	2.28	0.11	0.12

Note: *** = $p \leq 0.00$

Source: Prepared by the authors.

Finally, Tables 5 and 6 present the results of the association tests between variables for the *Year 1 ESO-StrMod* and *Year 4 ESO-StrMod* respectively.

Table 5. Tests for Association Between Variables: Year 1 ESO-StrMod

Association of variables	Regression weight				Standardised regression weight
	Estimate (B)	SE	CR	*p*	Estimate (β)
Positive emotions←Social networks	0.10	0.04	2.65	0.01**	0.10
Positive emotions←Traditional media	0.24	0.04	5.52	***	0.21
Positive emotions←Specialised sources	0.13	0.04	3.24	***	0.12
Positive emotions←Internal responsibility	0.04	0.01	4.15	***	0.16
Positive emotions←External responsibility	0.03	0.01	2.30	0.02*	0.09
Positive emotions←Risk perceptions	0.07	0.02	3.01	***	0.12

Negative emotions←Social networks	0.10	0.04	2.51	0.01**	0.08
Negative emotions←Traditional media	0.21	0.05	4.39	***	0.14
Negative emotions←Specialised sources	0.17	0.04	3.89	***	0.12
Negative emotions←Internal responsibility	0.02	0.01	2.03	0.04*	0.07
Negative emotions←External responsibility	–0.02	0.01	–1.09	0.28	–0.04
Negative emotions←Risk perceptions	0.37	0.02	15.08	***	0.52

Note: SE = Standard Error; CR = Critical Ratio; * = $p \leq 0.05$; ** = $p \leq 0.01$; *** = $p \leq 0.00$
Source: compiled by the author.

TABLE 6. Tests for Association Between Variables: Year 4 ESO-StrMod

Association of variables	**Regression weight**				**Standardised regression weight**
	Estimate (B)	**SE**	**CR**	***p***	**Estimate (β)**
Positive emotions←Social networks	0.16	0.04	3.71	***	0.15
Positive emotions←Traditional media	0.23	0.05	4.81	***	0.20
Positive emotions←Specialised sources	0.13	0.05	2.77	0.01**	0.12
Positive emotions←Internal responsibility	0.04	0.01	3.22	***	0.10
Positive emotions←External responsibility	0.04	0.02	2.27	0.02*	0.14
Positive emotions←Risk perceptions	0.06	0.03	2.40	0.02*	0.11
Negative emotions←Social networks	0.17	0.05	3.62	***	0.12
Negative emotions←Traditional media	0.23	0.06	4.14	***	0.14
Negative emotions←Specialised sources	0.17	0.05	3.29	***	0.11
Negative emotions←Internal responsibility	0.02	0.02	1.19	0.23	0.04
Negative emotions←External responsibility	–0.04	0.02	2.40	0.02*	–0.08
Negative emotions←Risk perceptions	0.43	0.03	15.21	***	0.57

Note: SE = Standard Error; CR = Critical Ratio; * = $p \leq 0.05$; ** = $p \leq 0.01$; *** = $p \leq 0.00$
Source: Prepared by the authors.

5. Discussion and conclusions

5.1. General structural model

The proposed *General-StrMod* explains 44% of the variance in the *negative emotions* construct through six endogenous variables (Figure 2), all of which have a statistically significant causal influence (Table 2). These results, together with the satisfactory model fit (Table 1), indicate that the proposed exploratory model is appropriate, particularly given the complexity and multidimensionality of emotions and the appraisal processes that underlie their elicitation (Moors *et al.*, 2013). They also support the robustness and relevance of the theoretical and empirical bases that underpin the proposed model.

The *General-StrMod* also explains 22% of the variance in the *positive emotions* construct through the six exogenous variables, all of which exert a significant causal influence (Table 2). In this case, the model accounts for almost a quarter of the variance in the intensity of *positive emotions*, which is an appropriate result given the complexity of emotional processes.

The theoretical-empirical bases of the *General-StrMod* are common to both emotional constructs, and the divergence in explained variance therefore requires analysis of the standardised regression weights (β coefficients). It is important to examine the possible moderating influence of categorical variables through multigroup analysis.

Because β coefficients allow the strength of causal influences between variables to be compared independently of measurement scale differences, the discussion is based on this coefficient.

In relation to the *Information Sources* block (Table 2), the frequency of consultation of *traditional media* shows the highest β value (0.20) for influence on *positive emotions* in the *General-StrMod*. By contrast, *specialised sources* and *social networks* display lower β values, which are similar to each other. The interpretation of the influence of *information sources* on the *emotional appraisal* of *positive emotions* largely depends on the accuracy and realism of the information conveyed through these media (Balleger *et al.*, 2024; Kollmuss & Agyeman, 2002; Ojala, 2022). In the absence of qualitative data on the type of information consulted, two hypotheses are proposed: 1) beneficial influence, where the increase results from access to realistic information about the capacity for climate action, progress in climate movements, environmental policies and so forth, creating a stronger sense of control and agency in relation to climate change (Hickman *et al.*, 2021; Ojala, 2022); and 2) harmful influence, where the increase is due to an unrealistic perception of control, shaped by discourses linked to *subtle forms of climate change denial* (Almirón & Moreno, 2022). In the case of *specialised sources*, which are typically managed by educators and climate activists, hypothesis 1 is considered more plausible, although this cannot be regarded as conclusive.

A similar pattern to that observed for *positive emotions* emerges in *negative emotions*, although with lower β scores. *Traditional media* has the second highest β value in the model, followed by *specialised sources* and *social networks* (Table 2). The hypotheses for their influence on *emotional appraisal* are as follows: 3) beneficial influence, where the increase is linked to realistic information about climate change that elicits negative feelings capable of motivating action without leading to immobilisation due to a perceived lack of control or capacity for action; 4) harmful influence, where the increase stems from overexposure to the consequences of climate change (present and future), including catastrophic narratives and/or a lack of clear connections to possible actions. As in the case of *positive emotions*, hypothesis 3 is considered more plausible for *specialised sources*.

The pattern of direct influence of *Information Sources* on both emotional constructs aligns with the hypothesis of González-Muñoz *et al.* (2024), who argued that more frequent consultation about climate change is associated with greater interest and heightened

emotional intensity, as proposed by the *appraisal theory* (Moors *et al.*, 2013). The SEM of the *General-StrMod* adds a further layer of discussion to this initial hypothesis, showing that: 1) the ordering of *traditional media*, *specialised sources* and *social networks* by β size is similar for both emotional categories, and 2) the β values for all *information sources* are somewhat higher in their influence on *positive emotions* than on *negative emotions*. These findings are consistent with those reported in other international studies (Ogunbode *et al.*, 2024).

The β values show a strong sense of *internal responsibility* for the causes of climate change on positive emotions, with the second highest coefficient in the model. *By contrast, external responsibility* attributed to Andalusia records the lowest value. Both exert a direct influence, yet the difference in β suggests that *internal responsibility* provides a greater sense of control over climate change and its evolution than *external responsibility*. These findings are consistent with the *appraisal theory of emotions* (Moors *et al.*, 2013) and with previous research on control (Domínguez, 2020; González-Muñoz *et al.*, 2024). As noted in relation to *information sources*, it is crucial that this sense of control be grounded in accurante information rather than in *subtle forms of climate change denial*.

For *negative emotions*, the β value of *internal responsibility* is relatively small (0.06). *External responsibility* shows the same value, but it is the only variable in the model with an inverse effect (-0.06). In this case, increases in *internal responsibility* are interpreted as producing a slight rise in the intensity of *negative emotions*, which the literature links to efforts to combat or prevent the underlying problem, provided individuals perceive a certain degree of control over the situation. By contrast, greater perceived *external responsibility*, which reduces the sense of personal responsibility, may encourage emotional disengagement from the problem, leading to a form of emotional 'short-sightedness' (Brosch, 2021; Moors *et al.*, 2013).

To conclude the analysis of *positive emotions*, *risk perceptions* show a direct influence. This finding contrasts with expectations, as the literature consulted in constructing the model points to an inverse relationship (Harth, 2021; Ojala, 2022; Schneider *et al.*, 2021; Smith & Leiserowitz, 2014). Further research is needed to explore this effect, which may attributable to variables not included in the *General-StrMod* or to the influence of moderating variables.

Risk perceptions exert a strong direct influence on *negative emotions*, with the highest βvalue of the *General-StrMod* (0.54) by a considerable margin, explaining much of the construct's variability. These results are consistent with the foundations of the model (Brosch, 2021; Meng *et al.*, 2023; Savadori & Lauriola, 2021). It is nonetheless essential that such perceptions be realistic and accompanied by knowledge and support for climate action, in order to reduce the risk of eco-anxiety, inaction or avoidant behaviours arising from viewing climate change as an overwhelming challenge.

5.2. Multigroup analysis of the *year group* variable: differences and similarities in emotional appraisal

The interpretation of the multigroup analysis of the *year group* variable drew on the descriptive-inferential analyses (Table 4), the β coefficients and their significance (Tables 5 and 6), and the significant results from the chi-squared difference tests of each structural relationship.

With regard to the significant difference by *year group* in the influence of *social networks* on both *positive* and *negative emotions*, participants from Year 4 ESO, (*Year 4 ESO-StrMod*) showed higher β values than those in Year 1 ESO (*Year 1 ESO-StrMod*), with differences of 0.05 for *positive emotions* and 0.04 for *negative emotions*. These divergences cannot be explained by significant differences in mean scores of the groups for frequency of consultation of *social networks* between the groups (Table 4). The results therefore suggest that students further advanced in their studies place greater importance on information obtained from *social networks*, both online (Twitter, Instagram, etc.) and

offline (friends and family) in their emotional appraisal of climate change. The difference in the influence of *social networks*, although not entirely clear, may be explained by various factors. In the online sphere, both the type of information consumed and the degree of credibility or authority attributed to it may play a role (Anguiano & Ilundain, 2021). In offline networks, while the effect also depends on the type of information and opinions shared, social acceptance and group identity become increasingly central during adolescence as individuals progress through this developmental stage, as highlighted in the conceptual framework of Ciranka and van den Bos (2019).

A significant difference was found on the influence of external responsibility on *negative emotions* by *year group*. Students from Year 4 ESO displayed a stronger inverse relationship (-0.08) than their younger counterparts (-0.04). Moreover, the significance of the *negative emotions* ß *external responsibility* relationship observed in the *General-StrMod* and in the *Year 4 ESO-StrMod* diminishes to the point of non-significance in the *Year 1 ESO-StrMod* (Table 5). By contrast, *internal responsibility*, although not showing a significant difference in its influence on the endogenous variables, does vary by *year group* in the significance of the β coefficient for *negative emotions* (Tables 5 and 6). Unlike *external responsibility*, the significance of the original direct relationship (*General-StrMod*) is maintained in the *Year 1 ESO-StrMod* but is lost in the *Year 4 ESO-StrMod*. Taken together, these results suggest that as students move through the Andalusian education system and, predictably, gain a greater understanding of the structural causes of climate change, they tend to externalise responsibility for its origins and escalation, thereby reducing their negative emotional load. In light of this, two hypotheses are proposed: 5) beneficial influence, where externalising causal responsibility allow students to reduce their *negative emotions*, helping them to avoid becoming overwhelmed or suffering eco-anxiety without diminishing their intention to act on climate change; and 6) harmful influence, where emotional detachment and denial of responsibility leads to disengagement from the phenomenon, encouraging avoidance and/or inaction.

6. Implications, limitations, and future lines of study

The *General-StrMod* shows a good level of fit, explaining almost half of the variance in *negative emotions* and almost a quarter in *positive emotions*. Both results are noteworthy, considering the inherent complexity and multidimensionality of emotions and the *emotional appraisal* processes that elicit them. The interpretation of the structural relationships in the *General-StrMod* provides a baseline for the field, underscoring the need for further multivariate studies at regional, national and international levels to test the generality of these findings. This study offers innovative and relevant contributions with implications for scientific research and for knowledge transfer across politics, society and communication.

In the field of education, these results have important implications for interventions and curriculum design in relation to climate change. Educators must address the climate crisis holistically, not only by covering conceptual aspects, but also recognising how information accessed by students outside the classroom influences their *emotional appraisal*. It is also essential to foster student perceptions of responsibility and risk that are realistic and oriented towards climate action. The findings show that students place more weight on information from *traditional media* than in *specialised sources*, even though the latter should in principle be more trustworthy and less likely to spread *subtle discourses of climate change denial*. This points to a need to reconsider which features of *traditional media* (e.g., audiovisual communication, the emotional tone of discourse, etc.) generate this imbalance, and to adopt more emotionally engaging and entertaining pedagogies such as game-based learning and other innovative or disruptive methodologies.

As students progress through ESO, they appear to place greater emotional weight on *social networks* (both online and offline) and to display an emotional pattern characterised

by a reduced sense of control over climate change, reflected in a significant decrease in *positive emotions* compared with Year 1 ESO and in the significant causal influence of *external responsibility* as an attenuator of *negative emotions.* It is therefore crucial at this educational stage to promote a critical and reflexive stance towards the information students consume and share, particularly on *social networks*, and to strengthen their emotional engagement with their own role in environmental action.

This study has several limitations. First, the absence of qualitative data restricts the interpretation of many of the results, making it necessary for the authors to propose hypotheses to address this gap. Second, although the sample size is adequate for SEM (n = 1.050), it is limited to the autonomous region of Andalusia, Spain. As the literature recognises emotional processes are influenced by numerous variables, including cultural and regional factors, any generalisation to national and international contexts should be made with caution. Third, the proportions of positive and negative emotions included in the questionnaire are uneven, which should be addressed in future instruments to capture the diversity of emotions more equitably. Fourth, the variance explained by the *General-StrMod* for *positive emotions* is half that explained for *negative emotions*, highlighting the need to incorporate additional variables into the model. Finally, the imbalance in ownership models among the schools surveyed may have introduced some bias.

Author contributions

Enrique González-Muñoz: Conceptualisation, data curation, formal analysis, methodology, resources, software, visualisation, writing (original draft), writing (reviewing and editing).

José Gutiérrez-Pérez: Conceptualisation, funding acquisition, investigation, methodology, project administration, resources, supervision, writing (original draft), writing (reviewing and editing).

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