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Complex pathways from nature relatedness and knowledge to pro-environmental behavior through eco-emotions

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ABSTRACT

Background and aim: In preventing the collapse of the ecosystem, individual behavior plays a crucial role alongside the action of global actors, but the complex possible pathways from nature relatedness and knowledge to pro-environmental behavior (PEB) through eco-emotions have not been widely studied. Thus, the current study aimed to explore the complex relationship between environmental knowledge, nature relatedness, different eco-emotions (anxiety, guilt and grief), general PEB and the intention to change behavior in the future.
Method: A representative sample of the Hungarian population (N = 1000) participated in an online study and answered questions about their environmental knowledge, PEB and intention to change their behavior, and completed the Nature Relatedness Scale, the Ecological Grief Questionnaire and the short versions of the Eco-anxiety Questionnaire and Eco-guilt Questionnaire.
Results: General PEB was directly associated with higher nature relatedness ($\beta = 0.223$, $SD = 0.032$), ecological grief ($\beta = 0.252$, $SD = 0.076$) and the negative consequences of anxiety ($\beta = 0.106$, $SD = 0.044$), while intention to change was directly associated with higher nature relatedness ($\beta = 0.190$, $SD = 0.034$), knowledge ($\beta = 0.131$, $SD = 0.032$, and eco-guilt ($\beta = 0.248$, $SD = 0.052$ and less negative consequences of anxiety ($\beta = -0.109$, $SD = 0.055$). Ecological grief and the negative consequences of anxiety positively mediated the effect of nature relatedness on general PEB, while the negative consequences of anxiety negatively mediated the effect of knowledge on general PEB and the effect of nature relatedness to the intention to change. Eco-guilt was a positive mediator between nature relatedness and intention to change.
Implication: By revealing and explaining the complex relationship system between nature relatedness, environmental knowledge and eco-emotions our article provides useful insights for environmental awareness raising efforts.

1. Introduction

There are more and more evident signals that without a profound change in the environmental behavior of people living in consumer societies, humanity could face more unprecedented ecological crises (Hahnel, 2011; Moore, 2017; UNEP, 2022). To mitigate the catastrophic warming of our climate, humankind must decrease its fossil energy consumption (Johnsson et al., 2019) and without changing red meat consumption habits, there is no real chance to develop sustainable agriculture and stop biodiversity to decrease (Popkin, 2009). If we could not change the habit of the mass use of single-use plastic items, and other short-lived and non-repairable consumer goods, there is no way to build a sustainable circular economy (European Academics Science Advisory Council, 2020).

These necessary changes could be realized only if consumers, producers, and decision-makers are all open and eager to act for them. If one of these social groups is hesitant, it is a very strong trigger for starting the well-known blaming game of social traps (Pereira-Heath and Chatzidakis, 2012). These social traps are especially dangerous because they hinder people's willingness to make their lifestyles individually and collectively greener by increasing resistance to change.

Due to the existing tendency of resistance to change both in

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organizations (Erwin and Garman, 2010) and in individuals (Oreg, 2003) the greatest challenge concerning pro-environmental behaviors (PEB) is not only to continue those PEBs which are already embedded in people's habits and social norms, but to introduce new ones either into individuals' life or into social norms. In other words, current pro-environmental behaviors will not solve the ecological crises humanity faces. There is also a profound need for the intention to continually seek more and more possibilities to make our lifestyles greener. If we live at least an average life in a developed country, the willingness to continuously make our life greener is a prerequisite for any significant environmental effect.

Therefore, it is an utmost task and responsibility for psychology to map the psychological factors behind not just people's current pro-environmental behaviors but also people's commitment to make their lifestyle greener in the very close future, namely, their intention to change their PEBs.

1.1. Literature review and theoretical framework

A growing number of studies aim to identify different determinants of pro-environmental behaviors (e.g., Blankenberg and Alhusen, 2019; Fujii, 2006; Sharma et al., 2023), but the more complex interrelations, i.e. the possible pathways from nature relatedness and knowledge to pro-environmental behavior (PEB) through the various types of eco-emotions have not been investigated. Also, studies generally focus on the psychological background that led to the current, realized pro-environmental behaviors and do not investigate what is behind people's openness to adopt further pro-environmental measures in their lives. Previous research has identified several factors influencing pro-environmental behaviors. One of the most extensively studied questions is to what extent the level of environmental knowledge leads to environmentally responsible actions. The definitions of environmental knowledge in previous studies cover a wide spectrum from having specific factual information on environmental issues to conceptual understanding of environmental phenomena, to self-definition of environmental knowledge by participants (Ardoin et al., 2015).

Research so far shows that there is a positive, but weak link between environmental knowledge and pro-environmental behaviors (e. g., Chawla and Cushing, 2007; Grilli and Curtis, 2021; Handayani et al., 2021). Several studies found that while subjective knowledge (one's belief about profoundness of her/his on knowledge) was associated with all kinds of PEBs, objective knowledge (the ability to answer environmental related question correctly) was associated with just certain types of PEBs (e. g., Casaló et al., 2019; Cologna et al., 2022; Ellen, 1994). In addition, the direction of the association between objective knowledge and pro-environmental behavior can be different in emerging and advanced countries (Vicente-Molina et al., 2013). Another study found on a representative Swiss sample that action-related knowledge and effectiveness knowledge have a direct effect on behavior, but system knowledge has not (Frick et al., 2004).

The classical knowledge -> attitude -> behavior model (Borden and Schettino, 1979), which inspired a significant amount of studies in the field of environmental education assumes that environmental knowledge helps to form positive environmental attitudes and positive environmental attitudes lead to PEBs. Recent theories argue that emotions could be considered as "specific type of attitudes" (Deonna and Teroni, 2015), and a strong thread of research has started to focus on the role of different eco-emotions in triggering or inhibiting pro-environmental behaviors. Thus, in this paper we examined whether eco-emotions could serve as mediators between environmental knowledge and pro-environmental behaviors as predicted by the knowledge-attitude-behavior model.

Although previous research has conceptualized different eco-emotions in various ways, a comprehensive taxonomy now has been created to describe them (Pihkala, 2022b), and several measurement tools have been developed to measure them, especially eco-anxiety (Clayton and Karazsia, 2020; Hogg et al., 2021; Stewart, 2021; Ágoston et al., 2022b). Eco-anxiety refers to the chronic fear or non-specific concern of environmental doom, which can manifest in emotional responses, but can also lead to various negative consequences, such as functional impairment (Ágoston et al., 2022a, 2022b). A related but distinct emotion is ecological grief, a current or anticipated feeling of loss or the loss of identity, which can occur in response to various phenomena of environmental degradation (Cunsolo and Ellis, 2018), and ecological guilt, which involves a perception of personal responsibility when people feel that they violated environmental norms (Mallett, 2012). There is growing scientific evidence that pro-environmental behaviors can be triggered by eco-anxiety (Lutz et al., 2023; Verplanken et al., 2020) and by other negative eco-emotions like anger (Stanley et al., 2021), grief and guilt (Ágoston et al., 2022b; Jiang et al., 2020) as well. Other studies show a positive link between certain positive emotions (e.g., hope) and environmentally conscious behavior (Sangervo et al., 2022). The role of eco-emotions in developing pro-environmental behavior and behavioral intent has been investigated in many areas. For example, Wang et al. (2023) found different levels of negative eco-emotions in the different stages of behavior change among dairy farmers. Both positive and negative emotions were shown to have positive associations with pro-environmental behaviors, such as energy conservation (Wang and Wu, 2016) and avoiding marine litter (Chen et al., 2023). A field study (Robina-Ramírez et al., 2020) showed that education of sustainability amplified emotions, which positively influenced environmentally conscious behavior among adolescents.

Furthermore, several studies have found a positive association between nature relatedness and pro-environmental behaviors (Keaulana et al., 2021; Zelenski and Desrochers, 2021). A large-scale European study found that connection to nature has a stronger impact on PEB than demographic variables (Iwińska et al., 2023). Nature relatedness is defined as the affective, cognitive, and experiential aspects of human–nature relationships (Nisbet et al., 2009), it includes peoples' positive feelings, preferential thoughts, and the willingness to spend time in natural environments. As the ecological problems are intertwiningly interconnected with the disappearance of natural environments around the world, it is evident that those who have positive attitudes toward nature will be more interested in environmental issues too.

As the role of environmental knowledge and nature-relatedness in the formulation of pro-environmental behaviors is theoretically so plausible, it raises the question of what causes these factors to show such a weak correlation with pro-environmental behavior. Why people do not simply behave rationally and perform as much PEB as possible when they learn about environmental problems, or when they develop a bond with nature? What factors are needed to realize the logical consequences of these psychological inputs?

The widely corroborated positive but weak correlations between nature relatedness, environmental knowledge and PEBs were the basis of our hypothesis, that other variables – e.g., emotions – may play a more important role in forming pro-environmental behavior or the intention to change and they may mediate the effects of knowledge and nature connection on these variables. Pooley and O'Connor (2000) have pointed out that although environmental education aims to increase PEB very often through increasing knowledge, many attempts fail; their findings suggest that emotions could play a crucial role in the success of environmental education programs. More knowledgeable people realize more PEB only if they have stronger environmental emotions. Perkins et al. (2021) argue that negative emotions like fear are amongst the most motivating factors concerning sustainability-related actions. Carmi et al. (2015) found no direct association between objective or subjective knowledge and PEB, but all the effects were mediated by environmental emotions. Environmental emotions were introduced in their model as a single variable including three components: connectedness to nature, biospheric concern and commitment. Raeisi et al. (2018) also identified the mediating role of emotions between knowledge and the sustainable use of groundwater in Iran. Therefore, the main hypothesis of the

current study is that eco-emotions will mediate the effect of environmental knowledge and nature relatedness toward pro-environmental behaviors and the intention to change (Fig. 1). We assume that a higher level of knowledge and a more positive relationship with nature will only lead to higher levels of action and intention to change if people also experience stronger negative emotions, namely anxiety, grief and guilt. As many previous studies have been conducted on convenience samples, we were particularly concerned to study how different demographic characteristics affect the pattern of these variables in a representative sample of the Hungarian population.

Summarizing the above considerations, a significant research gap could be identified in the literature. No previous study has combined the three main strands of research (nature-relatedness, eco-emotions, environmental knowledge) aiming to identify the determinants of pro-environmental behaviors and intentions on a representative sample. Therefore, the main aim of the present study was to investigate the complex relationship system between eco-emotions (eco-anxiety, eco-grief, eco-guilt) and environmental knowledge, nature relatedness, pro-environmental behavior and the intention to change in a more nuanced way than previous research.

The conceptual framework of our research is presented in Fig. 1.

2. Material and methods

2.1. Sample and procedures

Participants (N = 1000) were recruited via a survey company in the spring of 2022. Invitation e-mails were sent out by the survey company, data was collected using Qualtrics, an online survey software. 10845 respondents started the questionnaire on Qualtrics. 362 were eliminated, because they did not consent to participate in the study, while 446 respondents were eliminated, because they failed the attention checks. 9653 respondents did not finish the questionnaire; they were also eliminated. All the respondents who did not consent and some of the respondents who failed the attention checks are incorporated into the sum of respondents who did not finish the questionnaire, since in the first case the questionnaire did not let them continue and in the latter case some, but not all respondents stopped filling out sometimes after the control question, but before the end of the questionnaire. We monitored the progress of the recruitment process daily. We stopped the recruitment process once we reached 1000 valid, completed questionnaires. The sample is representative of the Hungarian adult population in terms of sex, age, region, and settlement size. We also attempted to achieve representativeness in terms of educational attainment, but due to the low participation rate of participants with primary education or less, we had to weight the sample in this respect. First, the informed consent was presented, and participants needed to indicate that they had read the consent and agreed with it to continue with the questionnaire. The demographic characteristics of the sample are presented in Table 1.

Table 1
Demographic characteristics of the sample.

Characteristics		N (%)
Sex	Male	470 (47)
	Female	530 (53)
Age	18–34	250 (25)
	35–44	210 (21)
	45–54	160 (16)
	55–65	170 (17)
	Above 65	210 (21)
Place of residence	Capital city	180 (18)
	County seat	170 (17)
	Other city	350 (35)
	Village	300 (30)
Region	Central Hungary	320 (32)
	Northern Hungary	120 (12)
	Northern Great Plain	140 (14)
	Southern Great Plain	120 (12)
	Western Transdanubia	100 (10)
	Central Transdanubia	110 (11)
	Southern Transdanubia	90 (9)
Educational attainment	Elementary school	240 (24)
	Vocational school	220 (22)
	High school	330 (33)
	College, university	210 (21)

The study was approved by the research team's university's ethics committee (number of the ethical approval: 2022/190).

2.2. Measures

2.2.1. Nature relatedness

One's connectedness to nature was measured by the 6-item Nature Relatedness Scale (NS-6) (Nisbet and Zelenski, 2013) (sample item: "I feel very connected to all living things and the earth."). The items are rated on a 5-point scale (1 = Strongly disagree, 5 = Strongly agree), and higher scores on the scale indicate higher nature relatedness. The internal consistency of the NS-6 in the Hungarian validation (Cronbach's alpha = 0.76) (Köteles, 2017) as well as in the current study (Cronbach's alpha = 0.72) was good.

2.2.2. Environmental knowledge

The 6 questions related to environmental knowledge were selected from the 12 environmental knowledge questions of the National Environmental Education and Training Foundation (NEETF) and Roper Starch Worldwide (Roper) survey of adult Americans (Kaplowitz and Levine, 2005; National Environmental Education and Training Foundation & Roper Starch Worldwide, 1997; 2001). Questions that were related to the U.S. geographically or in regulatory aspects, and thus less relevant to the Hungarian population, were not included. One of the six questions was related to the subjectively assessed knowledge of the participant and was used separately in the analysis. The other five

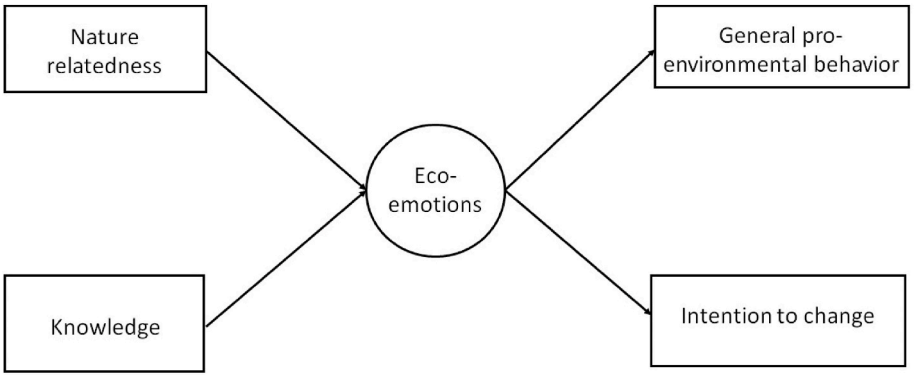


Fig. 1. The conceptual framework of the path analysis.

questions were related to biodiversity, renewable resources, ozone, hazardous waste and the most common reason that an animal species becomes extinct. The answer choice set was designed to have one correct, one conceivable but incorrect choice and two implausible options as well as a 'don't know' option (Kaplowitz and Levine, 2005). A total, weighted score of environmental knowledge was calculated after conducting a 3 pl item response theory (IRT) analysis. Based on their content, the items can be considered as measures of system-knowledge (Frick et al., 2004).

2.2.3. Ecological grief

For the assessment of ecological grief, we used the 6-item Ecological Grief Questionnaire (EGriQ-6) (Ágoston et al., 2022b). The EGriQ-6 is a one-factor questionnaire, which had excellent psychometric properties in a previous study (Cronbach's alpha = 0.77). It aims to measure the sense of loss associated with environmental destruction in one's closer and wider environment (sample item: "It is frightening that climate change is causing the destruction of natural areas at such a dramatic rate that they will never be the same again."). Participants rated each item on a 4-point scale (1 = Strongly disagree, 4 = Strongly agree), where a higher value represented higher ecological grief. The internal consistency of the EGriQ-6 in the current study was good (Cronbach's alpha = 0.84).

2.2.4. Eco-guilt

Eco-guilt was assessed by the short version of the Eco-guilt Questionnaire (Ágoston et al., 2022b). The one-factor original version consists of 11 items and it had excellent psychometric properties in a previous study (Cronbach's alpha = 0.89). We constructed the short version by selecting the four items with the highest factor loadings in the original survey (Item 6, 7, 8 and 9 of the original questionnaire). This questionnaire aims to measure the guilt associated with one's polluting or perceived pollution behavior, lack of action and role in the exacerbation of climate change (sample item: "The more I know about the human causes of climate change, the more things I feel guilty about."). Participants rated each item on a 4-point scale (1 = Strongly disagree, 4 = Strongly agree), where a higher value represented higher eco-guilt. The internal consistency of the short version of the Eco-guilt Questionnaire in the current study was good (Cronbach's alpha = 0.86).

2.2.5. Eco-anxiety

For the assessment of eco-anxiety, we used the short version of the Eco-anxiety Questionnaire (Ágoston et al., 2022b). The original version consists of two subscales: *habitual ecological worry* (Cronbach's alpha = 0.91), which reflects the emotional reactions (e.g., being terrified, alarmed, or worried) to the threat of consequences of climate change and the ecological crisis (sample item: "I am worried about the increasing number of natural disasters caused by climate change.") and *the negative consequences of anxiety* (Cronbach's alpha = 0.86), which represent functional and social impairment as well as tangible physical, emotional, or behavioral consequences related to eco-anxiety (sample item: "I sleep poorly because I keep thinking about climate change."). We constructed the short version by selecting the four items with the highest factor loadings from each factor in the original survey (Item 5, 7, 8, 9, 12, 13, 17 and 22 of the original questionnaire). Participants rated each item on a 4-point scale (1 = Strongly disagree, 4 = Strongly agree), where a higher value represented higher levels of the two types of eco-anxiety. The internal consistencies of the habitual ecological worry and the negative consequences of anxiety scales in the current study were good (Cronbach's alpha = 0.86 and 0.80, respectively).

2.2.6. Pro-environmental behavior

Pro-environmental behavior was measured by the modified version of the Pro-Environmental Behavior Questionnaire (PEBQ) (Ágoston et al., 2022b). The questionnaire was based on previous measurement tools (Brick and Lewis, 2014; Mónus, 2021; Prillwitz and Barr, 2011; Urien and Kilbourne, 2010) and we also added some self-developed items.

Twelve questions were rated on a 5-point scale, covering the following pro-environmental behaviors: sorting trash into the recycling bins (in public/at home); composting or reusing household food garbage; using reusable bags; eating meat; eating egg or dairy products; eating local food; saving energy; conserving water; using second-hand clothes; buying new things instead of repairing (reversed); boycotting products made by environmental offenders. One question, which was related to environmental activism was dichotomous with yes/no response options. One question, which was related to the furthest destination for vacation last year was rated on a 7-point scale. We measured car access with one question, then we asked participants which modes of transport they used the most frequently for four travel purposes.

We calculated a single index of general PEB to deal with some important issues related the measurement of PEB (e.g., multidimensionality and differences in behavior difficulties) (Kaiser, 1998). The general calculation process, which is based on a Rasch-model can be found in Appendix 1.

2.2.7. Intentions to change

Participants were asked the following question about the intention to change: 'What do you plan to change in your life in the next year to live more eco-friendly? You can select more than one answer.' (Szabó et al., 2023). We offered eight answer options: eating less food of animal origin, greener transport, less waste production, energy saving, greener clothing, choosing greener products when shopping, repairing things, nothing. The cumulative value of the intention to change was calculated by summing the first seven options.

2.3. Statistical analysis

We used the SPSS 25 (IBM Corp., 2011) for performing descriptive statistics, correlations, ANOVAs and Cronbach's alphas, and MPLUS 6.0 for the confirmatory factor analysis (CFA), exploratory structural equation modeling within confirmatory factor analysis (ESEM within CFA) and IRT-analysis (Muthén and Muthén, 1998–2011). ANOVAs or Welch-tests with Tukey or Games-Howell post hoc tests were used to explore the residence- and education-related differences in the studied variables. The correlations of the general PEB-score, the intention to change, environmental knowledge, nature relatedness, eco-anxiety, eco-guilt and ecological grief were examined as well.

To check the unidimensionality of the questionnaire related to environmental knowledge, we applied a CFA using a weighted least square parameter estimator (WLSMV). Model fit was investigated by using χ^2-test statistic, the Comparative Fit Index (CFI) (Bentler, 1990), the Root Mean Square Error of Approximation (RMSEA) (Steiger, 1990), and its 90% confidence interval (MacCallum et al., 1996). CFI was considered acceptable above 0.90 and excellent above 0.95, while RMSEA close to 0.06 and below 0.08 indicated an acceptable fit (Hooper et al., 2008; Hu and Bentler, 1999).

For the IRT analyses of the questionnaire related to environmental knowledge, the three-parameter (3 pl) model was calculated by using a maximum likelihood (ML) estimator, which contains a threshold parameter (b), a discrimination parameter (a), and a guessing parameter (c). The details of the IRT-analysis can be found in Appendix 2.

To examine the complex relationship between the variables, an ESEM within CFA analysis was applied, which incorporates the advantageous elements of both EFA and CFA, and constrains cross-loadings to be as close to zero as possible (Zyl and ten Klooster, 2022). We decided to apply this method instead of a common path analysis because it could handle the usually high correlations between the eco-emotion scales (Ágoston et al., 2022b). The ESEM code generator for Mplus developed by De Beer and Van Zyl (2019) was used to generate the syntaxes for the initial ESEM model. In the ESEM within CFA model, general PEB-score

and the intention to change were used as dependent continuous observed variables, environmental knowledge, and nature relatedness as continuous independent observed variables (sex and age were also included as covariates), and ecological grief, eco-guilt, and the two scales of eco-anxiety as continuous latent mediators. As the constructs were assessed by different types of Likert-scales, we report the standardized regression coefficients and their standard errors. The analysis was computed by using a robust maximum likelihood estimator. The χ^2-test statistic, the CFI, the RMSEA, and its 90% confidence interval were used to assess model fit.

To test convergent validity, the average variance extracted (AVE) approach was used. The scales were identified as separate when the square root of each AVE value was greater than the correlation between the two scales, and the AVE for each scale was greater than 0.50 (Fornell and Larcker, 1981).

3. Results

3.1. CFA and IRT analysis

The one-factor solution for the environmental knowledge questionnaire provided excellent model fit ($\chi2 = 3.1$, df = 5, p = 0.690; CFI = 1.000; RMSEA = 0.000 [CI: 0.000–0.034]), therefore, we could proceed with the IRT analysis. The criterion response parameters of the five knowledge-related items in the 3 pl model are presented in Appendix 2 – Supplementary Table 1 and the item characteristic curves (ICCs) for the items in the 3 pl model are presented in Appendix 2 – Supplementary Fig. 1.

The "guessing" parameter in the 3 pl model exceeded the suggested cut-off (Baker, 2001) for Item 4, therefore, we excluded this item for further analyses. Among the four items we kept, the question related to biodiversity was one of the most discriminating and also the most difficult (the correct answer to this question was more likely at a higher level of environmental knowledge), and the question related to extinction was the least discriminating and also the easiest item (the correct answer to this question was likely even in case of low level of environmental knowledge).

3.2. Comparison of the variables regarding residence and educational attainment

We found residence-related differences in five variables, with small effect sizes (Table 2). Those who live in the capital city or in a county seat, have higher knowledge than those who live in other cities or villages, while the latter two groups reported higher nature relatedness than those who live in county seats, and higher habitual ecological worry and ecological grief than those who live in the capital city. Those who live in the capital city reported less negative consequences of anxiety than the other three groups.

We found education-related differences in six variables, with small effect sizes (except for knowledge, where the effect was large) (Table 2). All groups were significantly different from each other in terms of knowledge: knowledge increased as educational attainment increased. Those with a primary education reported higher levels of general PEB and higher habitual ecological worry than those with a high school diploma or a college/university degree. They also reported more negative consequences of anxiety than those with a college/university degree, higher level of ecological grief than those with a high school diploma and higher level of eco-guilt than the three other groups.

3.3. ESEM within CFA analysis

The correlation matrix of the variables is presented in Table 3.

The initial, first-order ESEM model, which included the four eco-emotion scales had excellent fit indices ($\chi2 = 194.6$, df = 87, p < 0.001; CFI = 0.976; RMSEA = 0.035 [CI: 0.029–0.042]), therefore, we could proceed with the extended ESEM within CFA model, which also showed good fit ($\chi2 = 616.5$, df = 175, p < 0.001; CFI = 0.942; RMSEA = 0.050 [CI: 0.046–0.055]). The ESEM within CFA model with the significant standardized regression coefficients and their standard errors are depicted in Fig. 2.

Stronger nature relatedness positively predicted general PEB and future PEB intentions too. Stronger ecological grief and the negative consequences of eco-anxiety positively predicted only general PEB, while higher level of knowledge and stronger eco-guilt positively predicted only future PEB intentions. Interestingly, those who reported

Table 2
Residence- and education-related comparisons of knowledge, nature relatedness, eco-emotions, general pro-environmental behavior and the intention to change.

Variable	Residence						Educational attainment					
	Capital city (Mean [SD])	County seat (Mean [SD])	Other city (Mean [SD])	Village (Mean [SD])	F (df)	Partial eta squared	Primary school (Mean [SD])	Vocat. school (Mean [SD])	High school (Mean [SD])	College/ univ. (Mean [SD])	F (df)	Partial eta squared
Environmental knowledge	0.58 [0.29]^{a}	0.59 [0.31]^{a}	0.44 [0.30]^{b}	0.49 [0.31]^{b}	**16.95 (3, 996)**	0.05	0.34 [0.26]^{a}	0.42 [0.27]^{b}	0.53 [0.29]^{c}	0.69 [0.29]^{d}	**69.31 (3, 527.17)**	0.16
Nature relatedness	20.09 [4.19]^{ab}	19.66 [4.07]^{a}	20.66 [3.96]^{b}	20.67 [4.11]^{b}	**3.14 (3, 996)**	0.01	20.47 [4.05]	20.71 [4.11]	20.13 [4.02]	20.36 [4.17]	0.92 (3, 996)	
Habitual ecological worry	10.85 [3.08]^{a}	11.52 [2.76]^{ab}	11.65 [2.71]^{b}	11.68 [2.60]^{b}	**4.09 (3, 996)**	0.01	12.02 [2.53]^{a}	11.48 [2.83]^{ab}	11.35 [2.80]^{b}	11.14 [2.85]^{b}	**4.36 (3, 996)**	0.01
The negative consequences of anxiety	5.44 [1.91]^{a}	6.18 [2.02]^{b}	6.39 [2.11]^{b}	6.54 [2.28]^{b}	**12.58 (3, 478.25)**	0.03	6.47 [2.27]^{a}	6.46 [2.32]^{ab}	6.08 [2.05]^{ab}	5.95 [2.02]^{b}	**3.63 (3, 996)**	0.01
Ecological grief	15.07 [4.15]^{a}	15.95 [3.71]^{ab}	16.22 [3.41]^{b}	16.04 [3.48]^{b}	**3.44 (3, 454.59)**	0.01	16.49 [3.77]^{a}	15.97 [3.69]^{ab}	15.55 [3.70]^{b}	15.78 [3.30]^{ab}	**3.20 (3.996)**	0.01
Eco-guilt	7.65 [2.86]	8.19 [2.58]	8.13 [2.45]	8.33 [2.47]	2.41 (3, 457.85)		8.62 [2.60]^{a}	7.92 [2.50]^{b}	8.02 [2.50]^{b}	7.89 [2.61]^{b}	**4.21 (3, 996)**	0.01
General pro-environmental behavior	0.40 [0.17]	0.37 [0.17]	0.40 [0.17]	0.38 [0.17]	1.32 (3, 996)		0.41 [0.16]^{a}	0.39 [0.19]^{ab}	0.38 [0.15]^{b}	0.37 [0.15]^{b}	**3.38 (3, 526.09)**	0.01
Intention to change	3.01 [1.86]	2.98 [1.63]	2.98 [1.60]	2.90 [1.62]	0.21 (3, 996)		2.81 [1.70]	2.89 [1.70]	3.10 [1.68]	3.00 [1.54]	1.53 (3, 996)	

Note: Significant differences (p < 0.05) are marked with bold. Means without a common superscript are significantly different at least at p < 0.05. As effect size indicators, partial eta squared were calculated.

Table 3
Correlation matrix of the variables in the present study.

	Knowledge	nature relatedness	habitual ecological worry	negative consequences of anxiety	ecological grief	eco-guilt	general PEB
nature relatedness	−0.002						
habitual ecological worry	−0.043	**0.301**					
negative consequences of anxiety	**−0.171**	**0.311**	**0.392**				
ecological grief	−0.033	**0.442**	**0.699**	**0.425**			
eco-guilt	**−0.089**	**0.227**	**0.507**	**0.470**	**0.505**		
general PEB	−0.048	**0.349**	**0.195**	**0.242**	**0.315**	**0.163**	
intention to change	**0.115**	**0.248**	**0.219**	**0.120**	**0.236**	**0.250**	**0.231**

Note: Significant correlations ($p < 0.05$) are boldfaced. PEB: pro-environmental behavior.

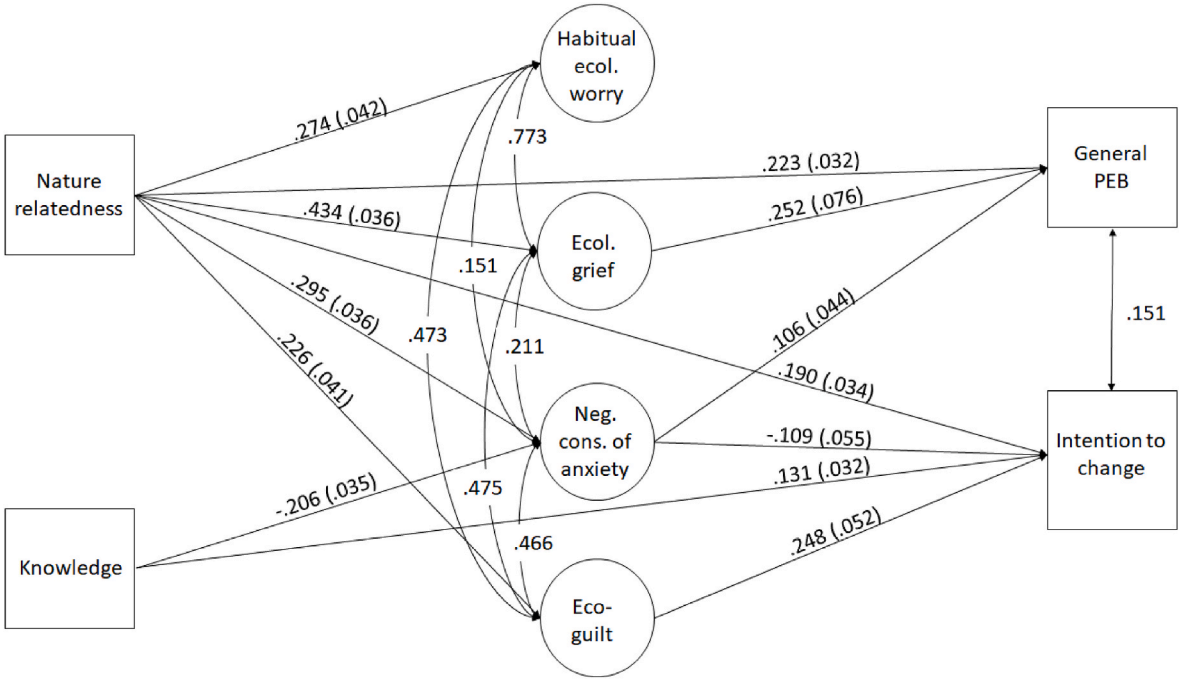


Fig. 2. – Path analysis for the association of nature relatedness, environmental knowledge, eco-emotions, general PEB and the intention to change (N = 999)
Note: Sex and age were included as covariates in the model. Being female was significantly associated with higher habitual ecological worry (β = 0.221, SD = 0.037), ecological grief (β = 0.171, SD = 0.038), eco-guilt (β = 0.124, SD = 0.040) and general PEB (β = 0.180, SD = 0.035), while higher age was associated with higher ecological grief (β = 0.109, SD = 0.037) and general PEB (β = 0.187, SD = 0.031). Values on the straight arrows represent standardized regression coefficients with their standard errors in parentheses. Values on the curved arrows represent covariances.

more negative consequences of anxiety had lower intention to change.

Nature relatedness was a positive predictor of all four eco-emotions, while those with higher knowledge experienced less negative consequences of anxiety. The factor loadings (Appendix 3 – Supplementary Table 2) were above 0.4 for every scale, which is acceptable according to Hair et al. (2019), and they were reasonably low on the other scales. The AVEs of the scales (Appendix 3) were close to or greater than 0.50, and the square root of each AVE value (Appendix 3) was greater than the correlation between the scales (except for the correlation between habitual ecological worry and ecological grief, see Fig. 2). The composite reliabilities of the scales (Appendix 3) were acceptable.

The significant indirect paths are summarized in Table 4.

In the case of a path with negative coefficients, (1) the higher level of knowledge was associated with less negative consequences of anxiety, which was associated with a lower level of general PEB, (2) higher nature relatedness was associated with more negative consequences of anxiety, which was associated with a lower level of intention to change. In the case of the paths with positive coefficients, the higher level of nature relatedness was associated with a higher level of a certain eco-emotion, which was associated with a higher level of general PEB or the intention to change.

Table 4
Indirect effects in the path analysis.

Indirect effects	β	S.E.
Knowledge → Negative consequences of anxiety → General PEB	−0.022[a]	0.010
Nature relatedness → Negative consequences of anxiety → General PEB	0.031[a]	0.014
Nature relatedness → Ecological grief → General PEB	0.109[b]	0.034
Nature relatedness → Negative consequences of anxiety → Intention to change	−0.032[a]	0.016
Nature relatedness → Eco-guilt → Intention to change	0.056[b]	0.017

Note: β = standardized regression coefficient, S.E. = standard error.
[a] $p < 0.05$.
[b] $p < 0.01$.

4. Discussion

The above presented model has revealed some possible pathways of formatting pro-environmental behavior, and intention to include more

pro-environmental behaviors into one's lifestyle. The main message of the model is that nature relatedness, environmental knowledge and eco-emotions provide a complex background for pro-environmental behaviors, and intentions.

4.1. Nature relatedness

Nature relatedness has a significant but weak association with general PEB and the intention to change and somewhat stronger associations with all investigated eco-emotions. These findings corroborate the results of former studies (Zelenski and Desrochers, 2021) indicating that promoting nature relatedness could be an effective way to promote pro-environmental behaviors and induce intention to engage in further pro-environmental behaviors.

4.2. Environmental knowledge

The results considering environmental knowledge are partly surprising. Although we found a very weak but significant direct positive effect of knowledge on the intention to change, we did not find this effect on PEB. As we measured system knowledge our results on the one hand corroborates Frick et al.'s (2004) results, that system level knowledge have no effects on PEB, but on the other hand the effect of system knowledge on intention to change proves that increasing system knowledge as a part of complex awareness-raising efforts could be an effective way of promoting a more pro-environmental lifestyle.

More surprisingly, contradicting several previous studies (e. g., Chawla and Cushing, 2007; Grilli and Curtis, 2021; Handayani et al., 2021), not only did we not find any direct positive effects, but we did find indirect negative effects of knowledge on PEB, mediated by the negative consequences of eco-anxiety – which also contradicts the results of Carmi et al. (2015). A possible explanation for this surprising result is that greater relevant knowledge may help emotion regulation (Koole, 2009), and consequently it can be a protective factor against the negative consequences of anxiety. Other possible explanation could be that more knowledge could lead people to search solutions on an intellectual level, namely 'smart' or technological solutions, which can, in fact, backfire: the techno-optimism they foster can reduce anxiety but also the sense of individual responsibility and hence action in the present (Ágoston et al., 2022a).

4.3. Mediating effects of emotions

The most novel aspect of our results is the identification of the complex mediating effects of emotions between nature relatedness and general PEB as well as intention to change. People are even more likely to take action in their daily lives when nature relatedness reaches such a high level that they experience the destruction of the nature they are attached to as a real loss, and a sense of sadness and grief or a stronger level of anxiety arises. The situation is quite different, however, if we look at the future intention to change: instead of grief, guilt had a positive mediating effect, while the negative consequences of anxiety was a negative mediator. In other words, if a connection to nature is accompanied by a growing sense of responsibility, it can motivate future action, while excessive anxiety can backfire. The latter link is a good illustration of the phenomenon of eco-paralysis: people see the problem as so threatening that they feel unable to act (Davenport, 2017). In addition, when anxiety becomes too intense, avoidance may be a possible coping response (Ágoston et al., 2022a): although established actions are maintained (as suggested by the positive correlation between anxiety and general PEB), the person may avoid news of the ecological crisis in order to protect their own mental well-being, which can lead to less future intention to act.

Our results about the two different factors of eco-anxiety could offer a possible explanation to the fact that previous research found only weak association between eco-anxiety/climate-anxiety and PEB (Clayton and Karazsia, 2020; Coffey et al., 2021). The results of the present study on ecological grief and eco-guilt shows that only the more specific and more elaborated feelings would lead either to PEB or the intention to change, while a low level general feeling of discomfort (which is represented by habitual ecological worry) is not motivating enough for people to perform pro-environmental behaviors or to formulate intention to make their lifestyle more environmentally friendly. The different effects of ecological grief and eco-guilt may also represent different stages of the coping process suggested by Pihkala (2022a): eco-guilt can be a main feeling in the early stage of the coping process when someone realizes their own contribution to the ecological crises and it ignites intention, while ecological grief can be a feeling associated to a more consolidated phase of the coping process when the individual already performs more PEB and does not intend to introduce new PEBs into their lifestyle. Future research and development of awareness raising programs should take into account this complex relationship pattern: educators should find a balance to increase nature-connectedness in a way that enhance the direct positive effects on PEB and intentions, and keep the motivating negative eco-emotions at a healthy level at the same time.

4.4. The role of demographic variables

Although most of the effect sizes for the comparison of different demographic groups were low, they draw attention to some notable differences that should be taken into account if we would like to utilize the results on a population level. The lower environmental knowledge of those who live in smaller settlements could be interpreted as a warning for the educational system to pay even more attention to eliminating inequalities. The improvement of educational opportunities would be advantageous on the long run, since our results show that the level of education indeed contribute to the improvement of environmental knowledge. For eco-emotions, we found opposite demographic patterns: people with higher educational attainment and those who live in larger settlements reported less eco-emotions, which might hinder pro-environmental actions.

4.5. The practical implications of the results

On a practical level, an important result is that knowledge was only a weak predictor of PEB and the intention to change, and it can also weaken the effects of eco-emotions; therefore, the traditionally information- and knowledge-based models of environmental education and awareness-raising should be shifted into a more emotion inclusive direction. Further studies should also explore the merits of helping highly educated and urbanized people to reconnect with not only nature but also with the sometimes painful emotions related to the deterioration of the ecosystem.

Another practical implication of our results is that although the three investigated eco-emotions (eco-anxiety, eco-guilt and eco-grief) could be perceived as painful, the evidence from our current study as well as previous studies (Lutz et al., 2023; Ogunbode et al., 2022; Sangervo et al., 2022; Stanley et al., 2021; Verplanken et al., 2020; Ágoston et al., 2022b) shows that they can be beneficial for the environment, and advantageous for people as well, by generating pride (Shipley and van Riper, 2022) and hope (Ojala, 2012). Further research should reveal what kind of coping mechanisms are optimal to cope with both the negative psychological consequences of eco-emotions and to help channel these emotions into long-standing pro-environmental behaviors (PEB) which also help to improve the mental health of people on the long run. Previous studies have revealed that problem-focused strategies (Ojala, 2012; Ágoston et al., 2024b) could contribute to these optimal coping outcomes, but further research is needed to reveal the long-term effects of applying these coping strategies in order to investigate whether these strategies really contribute to increasing people's PEBs permanently and decreasing the negative psychological consequences of eco-emotions at the same time. As previous studies found significant

individual differences in people's environmental commitment (Zsóka et al., 2013) and eco-emotions (Ágoston et al., 2024a) it could be reasonably assumed that different awareness-raising approaches should be identified for these different groups of people.

The importance of nature relatedness and eco-emotions as triggering factors for PEB has an important message for environmental education, too. Environmental educators should pay special attention to strengthening people's nature-connectedness, and significant space should be provided in curricula for not knowledge-oriented activities, which promote nature connectedness like free exploration in nature (Csonka, 2020), or mindful identification with natural beings (Lumber et al., 2023).

5. Conclusions

Our research provides clear evidence that there is a need to incorporate mediating variables into models describing the determinants of PEBs, because as Yuriev et al. (2020) concluded "Scholars tend to overlook mediating variables when predicting green behaviors." (p1.) We hope that our results help to develop more complex theoretical models explaining the psychological factors of the development of PEBs. The incorporation of eco-emotions, environmental knowledge and nature relatedness into the theory of planned behavior could be a promising direction of theoretical research.

Regarding nature relatedness, our study is a contribution to the growing scientific evidence that exposure to nature is not just simply beneficial to people's health and well-being, but also significantly contributes to the formation of PEBs in many ways. So, it can be concluded that a strong human-nature relatedness could be beneficial for both people and nature. Even as restoring natural habitats could help to tackle environmental crises like climate change (Dinerstein et al., 2019), the deepening human-nature connectedness could be beneficial not just on an individual but also on a social level by making societies more open to nature restoration efforts. Therefore, it is extremely important to find sustainable ways to provide access to nature for people in a continuously urbanizing world. Fortunately, the importance of restoration of nature recently has gained political momentum, like the Nature Restoration law of the European Union (European Commission Directorate-General for Environment, 2022), which requires restoring at least 20% of EU land and sea by 2030.

6. Limitations

The present study has some limitations. Although the sample is representative of the Hungarian adult population, it is cross-sectional, therefore, we cannot draw conclusions about the causal direction in the relationship between the variables. By applying a rigorous preliminary analysis on the environmental knowledge and general PEB, we could avoid certain distortions, but some limitations could stem from the choice of the set of items. We could have further differentiated some items in case of PEB (e.g., saving energy), and the set of items was limited to environmental knowledge and they focused mostly on system-knowledge. Further studies should include other types of knowledge (e.g., action-related knowledge and effectiveness knowledge) in complex models.

Statement of ethics

The authors complied with APA ethical standards in the treatment of the participants and the studies were approved by the Research Ethics Committee of the Faculty of Education and Psychology, ELTE Eötvös Loránd University (number of the ethical approval: 2022/190).

CRediT authorship contribution statement

Csilla Ágoston: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ágnes Buvár:** Writing – review & editing, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Andrea Dúll:** Writing – review & editing, Methodology, Conceptualization. **Zoltán Ábel Szabó:** Writing – review & editing, Visualization, Conceptualization. **Attila Varga:** Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2024.143037.

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