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► **To cite this version:**

Jean-Baptiste Pavani, Lucie Nicolas, Eric Bonetto. Eco-Anxiety motivates pro-environmental behaviors: a Two-Wave Longitudinal Study. *Motivation and Emotion*, 2023, 47 (6), pp.1062-1074. 10.1007/s11031-023-10038-x . hal-04467232

HAL Id: hal-04467232

<https://hal.science/hal-04467232v1>

Submitted on 20 Feb 2024

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Abstract

Recent studies suggest that eco-anxiety motivates pro-environmental behaviors. However, these studies are all cross-sectional in nature, and they frequently neglect possible important confounding variables (e.g., ecological identity). The present study was designed to deepen our understanding of the effect of eco-anxiety on pro-environmental behaviors by addressing the abovementioned limitations of recent research. The present study consisted of a 2-wave longitudinal study in which eco-anxiety and pro-environmental behaviors as well as possible confounding variables (i.e., ecological identity and personality) were assessed among French adults. As hypothesized, individuals' experience of eco-anxiety at t1 was positively and significantly related to individuals' engagement in pro-environmental behaviors at t2. This significant positive relationship was observed even when ecological identity, the Big Five domains of personality, and pro-environmental behaviors at t1 were controlled for. It thus appeared that compared with individuals with low levels of eco-anxiety at a given time, individuals with higher levels of eco-anxiety at a given time displayed a greater likelihood of experiencing increases in their subsequent engagement in pro-environmental behaviors. The results are discussed in light of current knowledge about the function of anxiety.

Keywords: eco-anxiety, pro-environmental behaviors, anxiety, problem solving, longitudinal.

Statements and Declarations

Data availability: Data as well as study materials and R codes are publicly available (https://osf.io/mtdyh/?view_only=ae0cdcf50194677bf476dc93a56d254).

Declarations of interest: None.

Funding: This research received no funding.

Eco-Anxiety Motivates Pro-Environmental Behaviors: A Two-Wave Longitudinal Study

1. Introduction

The global environmental crisis (e.g., climate change, global warming, ecological degradation, resource depletion, species extinction) represents one of the greatest contemporary threats to human survival and health (Intergovernmental Panel on Climate Change, 2022; World Health Organization, 2021). For instance, the direct effects of global warming (i.e., the effects of extreme acute weather events) include increased premature mortality from respiratory and cardiovascular disease, food- and water-borne illnesses, and hunger. Indirect effects of global warming (i.e., the effects of chronic climate change on social, economic, and natural ecosystems) are modifications in the geographical distribution of infectious diseases, lack of water quality, economic insecurity, or even involuntary migration (Centers for Disease Control and Prevention, 2022).

Importantly, individuals' awareness of this crisis is globally high. However, thinking about all these threats is not without mental costs for individuals (Ágoston et al., 2022; Boluda-Verdú et al., 2022; Hogg et al., 2021). For instance, when thinking about these threats, some individuals report experiencing aversive outcomes, such as an inability to stop or control worrying, feeling more anxious than they would like, or even having difficulty sleeping or accomplishing daily tasks (Boluda-Verdú et al., 2022; Hogg et al., 2021).

This set of emotions, cognitions and behaviors has been labeled *eco-anxiety* (Ágoston et al., 2022; Boluda-Verdú et al., 2022; Hogg et al., 2021). Eco-anxiety is aversive for individuals who experience it (Boluda-Verdú et al., 2022). Determining whether it is a useful experience is more complex. Does eco-anxiety motivate engagement in pro-environmental behaviors, or does it motivate the avoidance of events related to the environmental crisis?

Consistent with theoretical arguments on the function of anxiety (e.g., Carver & Scheier, 1990; McNaughton & Corr, 2004; Parsafar & Davis, 2018), recent studies suggest that eco-anxiety motivates pro-environmental behaviors (Innocenti et al., 2023; Schwartz et al., 2022; Stanley et al., 2021; Verplanken et al., 2020). However, although these studies are remarkable in several respects, they exhibit certain limitations. In particular, two main limitations can be identified. These studies all consist of cross-sectional studies, and they all neglect possible important confounding variables (e.g., ecological identity).

The present study was designed to deepen the current understanding of the effect of eco-anxiety on pro-environmental behaviors by addressing both limitations. It consisted of a 2-wave longitudinal study in which eco-anxiety and pro-environmental behaviors as well as possible confounding variables (i.e., ecological identity and personality) were assessed. Before presenting this study, we review below the reasons why we hypothesize that eco-anxiety motivates pro-environmental behaviors.

1.1. Anxiety and Problem-Solving Behaviors

Anxiety possesses three main features. First, it is a negative (i.e., unpleasant, painful) emotion (Parsafar & Davis, 2018; Yik et al., 2011). As such, anxiety represents an aversive state that individuals generally attempt to avoid (Nepon et al., 2010; Riediger et al., 2009). Accordingly, when individuals feel anxious, they are generally motivated to take action to make this emotion disappear or render it less intense (Daros et al., 2019; Rottweiler et al., 2023). Second, anxiety is an emotion high in arousal (Calvo & Miguel-Tobal, 1998; Yik et al., 2011). As such, it energizes behaviors because it motivates individuals and enables them to act urgently (Lang & Bradley, 2010; Storbeck & Clore, 2008). Third, anxiety causes specific threat-defense behaviors (D. C. Blanchard et al., 2001; McNaughton & Corr, 2004). In particular, anxiety is triggered in situations where threats are likely to appear or reappear. In these situations, anxiety fosters vigilance and risk assessment behaviors (i.e., behaviors designed to gain information about the intensity and probability of the

possible threat to come), seemingly to help individuals determine the future course of action (McNaughton & Corr, 2004; Wicker et al., 1985).

For these three reasons (i.e., being so aversive that individuals do not want to feel it, being so high in arousal that it energizes behaviors, and producing specific threat-management behaviors), anxiety can be hypothesized to motivate actions that aim to suppress the threat that triggered it (Bateson et al., 2011; Carver & Scheier, 1990; Parsafar & Davis, 2018; Weiner, 1985). More succinctly, anxiety can be hypothesized to motivate problem-solving¹ behaviors (Bateson et al., 2011; Carver & Scheier, 1990; Lazarus, 1993; Naragon-Gainey et al., 2017). A number of experimental studies lend support to this hypothesis. For instance, the results of studies in which anxiety is either experimentally increased through threat exposure or experimentally decreased through anxiolytic administration suggest that anxiety motivates information seeking about possible threats (Blanchard et al., 1997; Charpentier et al., 2022; Gray & McNaughton, 2000). When anxiety is experimentally increased, it is also found to motivate problem-solving behaviors (e.g., training in preparation for an upcoming test) even in a situation where more pleasant alternative activities are available (Xu et al., 2016). Interestingly, correlational studies also suggest that problem solving is one of the most frequently enacted behaviors in reaction to anxiety (Baumstarck et al., 2017; Garnefski et al., 2006).

However, the effect of anxiety on behaviors may be more complex. In particular, emotion regulation research suggests that dozens of effective ways to reduce anxiety can be enacted in addition to problem solving (Naragon-Gainey et al., 2017; Skinner et al., 2003). For instance, instead of suppressing the threat causing their anxiety (i.e., enacting problem solving), individuals can reduce their anxiety by orienting their attention away from the threat (e.g., Kraaij & Garnefski, 2019), seeking support from others (e.g., Battmann, 1988), dedramatizing the situation (e.g., Kappes & Schattke, 2022) or even exercising or using relaxation methods (e.g., Anderson &

¹ *Problem solving* has different meanings in different research fields. In this article, we use the meaning of *problem solving* that is commonly used in emotion regulation and coping research: problem solving refers to performing concrete actions to modify the event that causes aversive emotions (Naragon-Gainey et al., 2017; Skinner et al., 2003).

Shivakumar, 2013). Individuals differ in the value they assign to each of these ways to reduce anxiety, and problem solving is not preferred by all individuals (Naragon-Gainey et al., 2017; Skinner et al., 2003). Interestingly, anxiety even appears to have a detrimental effect on problem solving among certain individuals. In these individuals, anxiety fosters engagement in the repetitive rehearsal of negative thoughts (Garnefski & Kraaij, 2006; Pavani et al., 2017), in turn discouraging them from engaging in problem-solving behaviors (Lyubomirsky et al., 1999; Pavani et al., 2021). Finally, the effect of anxiety on problem-solving behaviors may change according to situational factors. Specifically, certain threats are uncontrollable or perceived as such, and problem-solving behaviors are devalued or considered impossible to enact by individuals who are confronted with these threats even when they feel anxiety (David & Suls, 1999; Yeung et al., 2016).

Because of these individual and situational moderators, the average positive effect of anxiety on problem-solving behaviors is presumably of a weak to moderate size. Nevertheless, for the theoretical (e.g., McNaughton & Corr, 2004; Parsafar & Davis, 2018; Storbeck & Clore, 2008) and empirical (e.g., Baumstarck et al., 2017; Charpentier et al., 2022; Xu et al., 2016) reasons mentioned above, we hypothesized that anxiety generally motivates problem-solving behaviors. The subsection below provides important information to determine whether this hypothesis can be supported in the domain of environmental issues.

1.2. Eco-Anxiety and Pro-Environmental Behaviors

At first glance, global environmental threats may appear to be problems over which individuals can exert little control. They may also appear as problems that individuals feel unable to resolve by themselves. However, several daily behaviors can actually be enacted by individuals to contribute to the resolution of these problems (e.g., eating less meat, using public transportation, turning off lights when leaving a room, limiting bath frequency and time in the shower, and becoming a member of any environmental protection group or contributing money to such a group; Markel, 2013). Therefore, global environmental threats are presumably viewed by individuals as

partly controllable. Environmental issues may thus be a domain in which anxiety generally motivates problem-solving behaviors.

Recent studies on the relationship between eco-anxiety and pro-environmental behaviors lend support to this hypothesis (Innocenti et al., 2023; Schwartz et al., 2022; Stanley et al., 2021; Verplanken et al., 2020). The results of these studies suggest that eco-anxiety is positively correlated with pro-environmental behaviors with a moderate effect size (i.e., an average correlation of $r = .33$; $SD = 0.15$). Thus, the higher individuals' eco-anxiety is, the greater their likelihood of engaging in pro-environmental behaviors (Innocenti et al., 2023; Schwartz et al., 2022; Stanley et al., 2021; Verplanken et al., 2020). Nevertheless, these results should be interpreted with caution as the abovementioned studies, albeit remarkable in several respects, display some limitations.

A first limitation involves the neglect of possible confounding variables (Frank, 2000; Skelly et al., 2012). The fact that eco-anxiety correlates with pro-environmental behaviors does not necessarily mean that eco-anxiety causes pro-environmental behaviors. Rather, it is conceivable that eco-anxiety correlates with pro-environmental behaviors only because both variables are caused by the same third variable. For instance, ecological identity (i.e., the degree to which an individual values ecology; Moussaoui et al., 2016) could cause both eco-anxiety and pro-environmental behaviors. Assigning greater importance to a goal (e.g., preserving the environment) is theoretically sufficient for producing more anxiety when this goal is threatened (e.g., more eco-anxiety) and more active engagement in the pursuit of this goal (e.g., pro-environmental behaviors; Austin & Vancouver, 1996).

A second limitation is the cross-sectional nature of all studies examining the relationship between eco-anxiety and pro-environmental behaviors (Innocenti et al., 2023; Schwartz et al., 2022; Stanley et al., 2021; Verplanken et al., 2020). Because these were cross-sectional studies, even if they had controlled for possible confounding variables, these studies would have been unable to determine whether the relationship between eco-anxiety and pro-environmental behaviors reflects a causal influence of eco-anxiety on pro-environmental behaviors or a reverse causal influence of

pro-environmental behaviors on eco-anxiety. To address these directionality-related questions, longitudinal studies are required (Talsma et al., 2018; Zyphur et al., 2020). In longitudinal studies, cross-lagged effects (i.e., the effect of a variable assessed at a given time on another variable assessed at a subsequent time while controlling for the initial level of this second variable) can be examined (Talsma et al., 2018; Zyphur et al., 2020). The temporal precedence of a variable in relation to another variable can thus be identified. Importantly, these temporal precedence phenomena are not firm proof of causality; however, they are considered important clues of such causality (Talsma et al., 2018; Zyphur et al., 2020).

1.3. The Present Study

The present study was motivated by the goal of deepening the current understanding of the effect of eco-anxiety on pro-environmental behaviors. This study attempted to examine this effect while addressing certain limitations of previous studies (i.e., the neglect of possible confounding variables and the neglect of temporal effects).

To address these limitations, this 2-wave longitudinal study assessed not only eco-anxiety and pro-environmental behaviors but also possible confounding variables (i.e., ecological identity and personality). We hypothesized that eco-anxiety at t1 would have a positive effect on pro-environmental behaviors at t2 even when pro-environmental behaviors at t1, ecological identity and the Big Five domains of personality were controlled for. Ecological identity was examined as a control variable because it can consist of a common cause of eco-anxiety and pro-environmental behaviors (Austin & Vancouver, 1996; Moussaoui et al., 2016). The control variables we examined also included the Big Five domains of personality due to their wide coverage of the entire set of traits with regard to which individuals can differ from each other (John, 1990).

2. Method

2.1. Participants

The sample size was determined with a power analysis, which was computed by using the *pwr* R package (Champely, 2020). As described more fully in the *Data Analytic Strategy* subsection, our main hypothesis could be tested with a multiple regression analysis including pro-environmental behaviors at t2 as the outcome variable and pro-environmental behaviors at t1, eco-anxiety at t1 and confounders as predictor variables. On the basis of the extant literature on autocorrelations among adult individuals (e.g., Roberts & DelVecchio, 2000), we expected the effect of pro-environmental behaviors at t1 on pro-environmental behaviors at t2 to be very strong (i.e., $\beta = 0.75$; 56.25% of the variance explained). To achieve 80% power with a nonnegligible effect of eco-anxiety at t1 above and beyond pro-environmental behaviors (i.e., $\beta = 0.15$; an additional 2.25% of the variance explained) with a significance level of 0.05, a sample size of at least 147 individuals was required.

To reach at least this sample size, the recruitment method that we used was *convenience sampling* due to its recognized efficiency (Etikan et al., 2016). By presenting the study as a scientific inquiry of people's own relationship with the environment, we found volunteers to participate via our personal and professional networks and through advertisements posted on social media. Flyers were also posted inside the authors' university. Only one exclusion criterion was applied (i.e., being below the age of 18). Participants did not receive any financial compensation for their participation.

With this strategy, we obtained a sample of 167 French adults (65% female, 35% male, 0% other) aged 18-76 years ($M = 37.80$, $SD = 14.86$) who responded at t1 and t2. The participants' education level was generally high (5% had no high-school diploma, 12% had a vocational high-school diploma, 27% had a general high-school diploma, 34% had completed 2 years of higher education, and 23% had completed more than 2 years of higher education). At t1, responses from 350 participants (69% female, 31% male, 0% other, $M_{age} = 34.81$, $SD_{age} = 14.90$) were collected. However, approximately 52% (i.e., 183 individuals) did not respond at t2. Importantly, the participants who dropped out between t1 and t2 did not differ significantly from the participants who remained involved with regard to gender ($\chi^2 = 3.06$, $p = 0.216$), education level ($t = -1.47$, $p =$

0.143, $d = -0.16$), eco-anxiety ($t = 0.92$, $p = 0.359$, $d = 0.10$), ecological identity ($t = -0.37$, $p = 0.711$, $d = -0.04$), neuroticism ($t = 1.56$, $p = 0.120$, $d = 0.17$), extraversion ($t = -0.76$, $p = 0.449$, $d = -0.08$), openness/intellect ($t = -0.37$, $p = 0.714$, $d = -0.04$), agreeableness ($t = -0.11$, $p = 0.910$, $d = -0.01$), and conscientiousness ($t = -0.68$, $p = 0.500$, $d = -0.07$). However, the participants who dropped out between t1 and t2 were younger ($t = -3.65$, $p < 0.001$, $d = -0.39$) and slightly less inclined to perform pro-environmental behaviors ($t = -2.48$, $p < 0.05$, $d = -0.27$) than the participants who remained involved.

2.2.Procedure

The procedure was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from each participant. Participants were informed that the study was longitudinal; however, they were also told that they could leave the study at any time without providing any justification.

A two-wave procedure identical to the procedure used in prospective studies was applied. In the first wave (i.e., t1), participants completed an online questionnaire battery that featured (1) a question inviting them to provide a personal code², (2) a sociodemographic questionnaire inviting them to indicate their gender, age and education level, and (3) questionnaires assessing psychological characteristics (i.e., eco-anxiety, pro-environmental behaviors, ecological identity, and personality). In the second wave (i.e., t2), participants completed a shorter online questionnaire battery that featured (1) a question inviting them to again provide the anonymized personal code they had provided at t1 and (2) the same eco-anxiety and pro-environmental behavior questionnaires they had completed at t1.

The invitation to complete the t2 questionnaire battery was sent by email to participants approximately 21 days after their completion of the t1 questionnaire battery. A reminder was sent by

² Participants were asked to provide the same personal code at t1 and t2, and this code served to combine each participant's responses to both waves.

email again approximately 7 days later (i.e., 28 days after completion of the t1 questionnaire battery) to the participants who had not completed the t2 questionnaire battery. These timings were chosen to allow t1 and t2 to be separated by approximately 4 weeks because we expected numerous participants not to respond immediately after receiving the initial t2 invitation. The interval between t1 and t2 responses was 31.86 days on average ($SD = 4.19$, $min = 22$, $max = 45$).

2.3. Materials

Eco-anxiety. Eco-anxiety was assessed by using the *Hogg Eco-Anxiety Scale* (Hogg et al., 2021). This questionnaire invites participants to indicate the frequency with which, over the past 2 weeks, they were bothered by 13 unpleasant reactions (e.g., *feeling nervous, anxious, or on edge*) when they thought about environmental threats. Responses are provided on 4-point Likert scales ranging from 0 (never) to 4 (almost always). Because this questionnaire was not validated in French, we translated it via the so-called *blind parallel method* (Shaw & Onkvisit, 2004). We then administered it to a pretest sample of 200 participants to test its validity (see OSF files), which appeared to be satisfactory. In particular, confirmatory factor analysis suggested that a 1-factor solution fit the data well, a result that we replicated in this study's sample ($CFI = 0.93$, $TLI = 0.91$, $RMSEA = 0.08$, $SRMR = 0.08$). On this basis, we computed a single indicator of eco-anxiety by averaging scores for the 13 items (for t1: $\alpha = 0.91$; for t2: $\alpha = 0.94$)³.

Pro-environmental behaviors. The performance of pro-environmental behaviors was assessed by using the *Pro-Environmental Behavior Scale* (Markle, 2013). This questionnaire contains 19 items that ask individuals to indicate whether they generally engage in pro-environmental behaviors (e.g., *How often do you limit your time in the shower to conserve water?*). The Likert scales differ between items; however, they systematically range from 1 (minimal score) to 5 (maximal score). Similar to the *Hogg Eco-Anxiety Scale*, the *Pro-Environmental Behavior*

³The OSF files mentioned are available at https://osf.io/mtdyh/?view_only=ae0cdcfd50194677bf476dc93a56d254. In this study, responses to items of the *Hogg Eco-Anxiety Scale* were scored from 1 to 4 to make their comparison with the other questionnaires that we used easier. In addition, all alpha coefficients computed in this study consist of the alpha coefficients for ordinal variables proposed by Zumbo et al. (2007).

Scale was not validated in French. Therefore, we translated its items using the same method as for the *Hogg Eco-Anxiety Scale* and administered the French version to the abovementioned pretest sample. To achieve satisfactory validity indicators, 5 items had to be removed (see OSF files for details). A 1-factor solution computed on the remaining 14 items fit the data well not only in the pretest sample (see OSF files) but also in this study's sample ($CFI = 0.93$, $TLI = 0.91$, $RMSEA = 0.04$, $SRMR = 0.06$). On this basis, we computed a single indicator of pro-environmental behaviors by averaging scores for the 14 items (for t1: $\alpha = 0.78$; for t2: $\alpha = 0.75$).

Control variables. Possible confounding variables were assessed, namely, *ecological identity* and *the Big Five domains of personality*. Ecological identity was assessed by using the French validation of the *Environmental Attitude Inventory* (Moussaoui et al., 2016). Its brief version invites individuals to indicate the degree to which they agree with 12 statements (e.g., *Humans are severely abusing the environment*) on 9-point Likert scales ranging from 1 (strongly disagree) to 9 (strongly agree). Averaging scores for the 12 items yielded the indicators of ecological identity used in this study ($\alpha = 0.73$). The Big Five domains of personality were assessed using the French validation of the *Big Five Inventory* (Plaisant et al., 2010). This questionnaire asks participants to rate the degree to which they agree with 45 different statements on 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). In this questionnaire, 8 items assess neuroticism (e.g., *I am someone who worries a lot*), 8 items assess extraversion (e.g., *I am someone who is outgoing and sociable*), 10 items assess openness/intellect (e.g., *I am someone who is very imaginative*), 10 items assess agreeableness (e.g., *I am someone who generally trusts others*), and 9 items assess conscientiousness (e.g., *I am someone who works conscientiously*). Averaging scores for the items designed to assess each of these domains yielded the indicators of neuroticism ($\alpha = 0.92$), extraversion ($\alpha = 0.88$), openness/intellect ($\alpha = 0.85$), agreeableness ($\alpha = 0.79$), and conscientiousness ($\alpha = 0.86$) used in the analyses reported below.

2.4. Data Analytic Strategy

All analyses were computed by using R (R Core Team, 2022). The dataset on which our analyses were based and the R script that we used are contained in files available at https://osf.io/mtdyh/?view_only=ae0cdcfd50194677bf476dc93a56d254.

After calculating traditional descriptive statistics, the data analysis strategy that we followed consisted of performing a regression analysis in which pro-environmental behaviors at t2 were regressed on eco-anxiety at t1. Pro-environmental behaviors at t1 were also included in the predictors to prevent temporal effects from being confounded with contemporaneous effects, as is commonly done in longitudinal studies (Zyphur et al., 2020). The interaction between eco-anxiety at t1 and pro-environmental behaviors at t1 was also included in the predictors because recent studies suggest that one variable (e.g., eco-anxiety) can exert a lagged influence on another variable (e.g., pro-environmental behaviors) that depends strongly on individuals' baseline levels on this variable (e.g., pro-environmental behaviors at t1; Antoine et al., 2018; Pavani et al., 2019). Finally, ecological identity and the Big Five domains of personality were also included in the predictors to control for their possible confounding effects.

3. Results

3.1. Descriptive Statistics and Correlational Analyses

Descriptive statistics and intercorrelations between the variables of interest are presented in Table 1. Three possibly interesting results emerged at this descriptive level. First, eco-anxiety and pro-environmental behaviors were positively correlated (for t1: $r = 0.29, p < 0.001$; for t2: $r = 0.38, p < 0.001$)⁴. Second, both eco-anxiety ($r = 0.25, p < 0.01$) and pro-environmental behaviors ($r = 0.57, p < 0.001$) were positively correlated with ecological identity. Third, while the strongest personality correlate of eco-anxiety was neuroticism ($r = 0.40, p < 0.001$), the strongest personality correlate of pro-environmental behaviors was openness/intellect ($r = 0.20, p < 0.05$).

⁴ These correlations between eco-anxiety and pro-environmental behaviors remained positive even when ecological identity and the Big Five personality traits were partialled out (for t1: *partial* $r = 0.26, p < 0.001$; for t2: *partial* $r = 0.41, p < 0.001$).

(Insert Table 1 approximately here.)

3.2. Hypothesis Testing

The results of the multiple regression that we performed are presented in Table 2. As is commonly observed in longitudinal studies (e.g., Roberts & DelVecchio, 2000), the strongest predictor of pro-environmental behavior at t2 was its lagged version at t1 ($\beta = 0.77, p < 0.001$). Nevertheless, as hypothesized, eco-anxiety at t1 significantly and positively predicted pro-environmental behaviors at t2 over and above pro-environmental behaviors at t1 ($\beta = 0.15, p < 0.01$)⁵. For clarity, both effects are simultaneously depicted in Figure 1. This graphical representation is derived from predictions made on the basis of the coefficients estimated by the multiple regression analysis⁶. In this figure, eco-anxiety at t1 appears to predict pro-environmental behaviors at t2 mainly among individuals who scored low on pro-environmental behaviors at t1. However, this interaction between eco-anxiety at t1 and pro-environmental behaviors at t1 held only at the descriptive level and was nonsignificant ($\beta = -0.04, p = 0.366$)⁷.

(Insert Table 2 and Figure 1 approximately here.)

⁵ Interestingly, if we perform this analysis for each item of the *Pro-Environmental Behavior Scale* (Markle, 2013), the item impacted the most by eco-anxiety at t1 (i.e., $\beta = 0.19, p < 0.01$) referred to a public behavior (i.e., *How often do you talk to others about their environmental behavior?*).

⁶ As described in Antoine et al. (2018) and Pavani et al. (2019), the type of graph chosen is useful for representing how the lagged version of a variable (e.g., pro-environmental behaviors at t1) and another variable (e.g., eco-anxiety at t1) exert an additive or interactive effect on the subsequent state of the former variable (e.g., pro-environmental behaviors at t2). In our graph, the individuals who increased their pro-environmental behaviors from t1 to t2 are above the diagonal.

⁷ We also analyzed whether change in eco-anxiety from t1 to t2 could explain pro-environmental behaviors at t2 more than eco-anxiety at t1. For this purpose, we computed the change in eco-anxiety from t1 to t2 in the form of a residualized change score, which we included among the predictors in our main analysis. We observed that although this variable significantly predicted pro-environmental behaviors at t2 ($\beta = 0.13, p < 0.01$), its predictive power was not stronger than the predictive power of eco-anxiety at t1 ($\beta = 0.18, p < 0.001$).

3.3. Supplementary Analyses

The hypothesis that anxiety impacts problem-solving behaviors in an inverted U-shaped manner is influential in psychology research (e.g., Muse et al., 2003; Peifer et al., 2014). Consequently, we decided to test whether eco-anxiety at t1 influenced pro-environmental behaviors at t2 in an inverted U-shaped manner. To this end, we performed the abovementioned multiple regression analysis again while including in the predictors the linear effect of eco-anxiety at t1 and its nonlinear quadratic effect. Detailed results are provided in the OSF files (see Table S1). Briefly, the quadratic effect of eco-anxiety at t1 on pro-environmental behaviors at t2 was almost null and nonsignificant ($\beta = -0.01, p = 0.743$). Therefore, eco-anxiety did not predict subsequent pro-environmental behaviors in an inverted U-shaped manner.

Another influential hypothesis in psychology research is that the impact of anxiety on problem-solving behaviors differs between individuals according to their personality (e.g., Pavani et al., 2021; Robinson et al., 2010). For instance, it has sometimes been observed that the higher individuals' neuroticism is, the stronger their inclination is to reduce their problem-solving behaviors in reaction to anxiety states (Lyubomirsky et al., 1999; Pavani et al., 2021). Consequently, we also decided to test whether eco-anxiety at t1 could influence pro-environmental behaviors at t2 differently according to individuals' personality. To achieve this goal, we performed our main multiple regression analysis once again while including in the predictors not only the simple effect of eco-anxiety at t1 but also its interactive effect with neuroticism, extraversion, openness/intellect, agreeableness, and conscientiousness. Detailed results are provided in the OSF files (see Table S2). It appeared that eco-anxiety did not significantly interact with any of these personality indicators to predict pro-environmental behaviors at t2 (for neuroticism: $\beta = 0.04, p = 0.430$; for extraversion: $\beta = 0.01, p = 0.850$; for openness/intellect: $\beta = 0.02, p = 0.749$; for agreeableness: $\beta = 0.06, p = 0.238$; for conscientiousness: $\beta = -0.01, p = 0.839$). Therefore, individual differences in the degree to which eco-anxiety predicted subsequent pro-environmental behaviors were not explained by the Big Five personality dimensions.

Finally, research on emotions and problem-solving behaviors frequently examines the reverse influence that problem solving exerts on emotions (e.g., Carver & Scheier, 1990; Pavani et al., 2021). Therefore, we decided to study not only the effect of eco-anxiety at t1 on pro-environmental behaviors at t2 but also the reciprocal influence of pro-environmental behaviors at t1 on eco-anxiety at t2. As is classically done in the study of bidirectional relationships, we performed a cross-lagged panel model (Zyphur et al., 2020). Detailed results are displayed in the OSF files (see Table S3). The results suggest that more eco-anxiety at t1 predicted more pro-environmental behaviors at t2 ($\beta = 0.15, p = 0.01$), and more pro-environmental behaviors at t1 predicted more eco-anxiety at t2 ($\beta = 0.11, p < 0.05$). In other words, with a 1-month lag, eco-anxiety and pro-environmental behaviors reciprocally reinforced each other.

4. Discussion

4.1. Interpretation of Results

The main result obtained in the present study was that eco-anxiety motivated pro-environmental behaviors. As we hypothesized, individuals' experience of eco-anxiety at a given time (t1) was positively and significantly related to their engagement in pro-environmental behaviors one month later (t2). This significant positive relationship was observed even when ecological identity, the Big Five personality domains, and pro-environmental behaviors at t1 were controlled for. It thus appears that individuals with higher levels of eco-anxiety at a given time (compared with individuals with low levels of eco-anxiety) display a greater likelihood of experiencing increases in their subsequent engagement in pro-environmental behaviors. This result is consistent with all the theoretical (e.g., McNaughton & Corr, 2004; Parsafar & Davis, 2018; Storbeck & Clore, 2008) and empirical (e.g., Baumstarck et al., 2017; Charpentier et al., 2022; Xu et al., 2016) arguments suggesting that anxiety generally motivates problem-solving behaviors. It is also consistent with arguments suggesting that anxiety still exerts this effect on behaviors in the domain of environmental threats (Innocenti et al., 2023; Schwartz et al., 2022; Stanley et al., 2021; Verplanken et al., 2020).

The supplementary analyses that we performed also yielded possibly interesting findings. For instance, while the hypothesis that anxiety can impact problem-solving behaviors in an inverted U-shaped manner is influential in psychology research (e.g., Muse et al., 2003; Peifer et al., 2014), eco-anxiety had only a linear effect on pro-environmental behaviors in the present study. Actually, this result is consistent with most previous findings, as the inverted U-shaped effect hypothesis has frequently been infirmed (Muse et al., 2003). Two explanations for this situation can be proposed. The first such explanation is terminological. The initial studies that led to the influence of the inverted U-shaped effect hypothesis analyzed *stress*, which was defined as a high-arousal state that is neither positive nor negative. This definition departs from the more common definition of *stress* subsequently adopted, according to which stress is a synonym of anxiety and thus represents a negative high-arousal state (Muse et al., 2003). The second explanation entails the state/trait distinction. In the initial studies that led to the influence of the inverted U-shaped effect hypothesis, states were induced just before the problem-solving task. In contrast, in the present study, eco-anxiety was assessed over the 2-week period mentioned in the instruction included in the *Hogg Eco-Anxiety Scale* (Hogg et al., 2021).

Another possibly interesting result obtained via our supplementary analyses was more unexpected. Individuals' engagement in pro-environmental behaviors at a given time (t1) was positively and significantly related to their experience of eco-anxiety one month later (t2), even after controlling for ecological identity, the Big Five personality domains, and eco-anxiety at t1. Not only was this lagged effect of pro-environmental behaviors on eco-anxiety positive; the contemporaneous relationship between the two variables was also positive. This result is inconsistent with empirical arguments suggesting that problem solving is one of the most effective strategies for reducing negative emotions (Aldao et al., 2010). This unexpected result may nevertheless be understood in theoretical terms. According to emotion regulation theories (e.g., Gross, 2015), the main reason why problem solving can reduce negative emotions is that it concretely moves individuals' states (e.g., *I find myself in a natural park degraded by waste*

carelessly left by travelers.) closer to their goals/ideals (e.g., *After a day of work, the natural park is now rid of this waste.*). It logically follows that problem solving can increase negative emotions in two cases. The first such case is that problem solving could ironically increase the problem (i.e., move individuals' state further from their goals/ideals). To our knowledge, this possibility is unlikely. With regard to the simple example mentioned above, spending time ridding a natural park of waste is unlikely to result in a situation in which the park contains more waste. The second case is that, although problem-solving behaviors are effective in solving the problem at hand, they may increase the likelihood of encountering other such problems in the future (e.g., *Even if my pro-environmental group and I have succeeded in ridding this natural park of waste, we will continue to be informed of other cases in which natural spaces are degraded in the following days.*). This second explanation seems to be more likely; however, future research is needed to (1) replicate this positive lagged effect of pro-environmental behaviors on eco-anxiety and (2) if the effect is replicated, uncover the mechanisms that explain (i.e., mediate) this effect.

4.2. Implications

The abovementioned results may have theoretical implications. First, they provide information about the function of anxiety. For some researchers of emotion or motivation, the main function of anxiety is the motivation of problem-solving behaviors (Carver & Scheier, 1990). For other emotion or motivation researchers, its main function is to motivate problem-solving behaviors in the environment in which it evolved, suggesting that anxiety may be less functional in today's environment (Bateson et al., 2011). Contradictory arguments stating that anxiety mostly serves learning and decision-making rather than problem-solving motivation are also influential (Baumeister et al., 2009). The present study's results lend support for the hypothesis that in today's environment, anxiety tends to motivate problem-solving behaviors. Second, these results provide information on eco-anxiety. Previous studies that were cross-sectional in nature observed that eco-anxiety is a correlate of pro-environmental behaviors (Innocenti et al., 2023; Schwartz et al., 2022; Stanley et al., 2021; Verplanken et al., 2020). Our results from a study that was longitudinal in

nature lend support to the hypothesis that eco-anxiety causes pro-environmental behaviors, although temporal precedence is just a clue of causality (Zyphur et al., 2020).

For some readers, our results may also have political implications, although we are more doubtful about this. The observation that eco-anxiety motivates pro-environmental behaviors does not necessarily lead to the conclusion that pro-environmental politicians or activists should use anxiogenic arguments to persuade individuals to adopt pro-environmental behaviors. First, in terms of ethics, the end does not necessarily justify the means. Anxiety is a painful emotion that certain individuals find difficult to regulate (Szuhanı & Simon, 2022). Accordingly, its deliberate induction for political purposes is highly problematic. Second, in terms of effectiveness, it is not because eco-anxiety motivates pro-environmental behaviors that there are no other effective ways to accomplish this goal (Elliot, 2008). Individuals are not motivated only by the wish to avoid the negative emotions they dread feeling when they encounter a threat or experience a loss. Rather, individuals are also motivated by the positive emotions they envision themselves experiencing when anticipating a reward (Elliot, 2008). Therefore, theoretically, pro-environmental speeches based on what we can gain by engaging in pro-environmental behaviors are likely to be as effective as speeches that focus on what we can avoid losing by engaging in such behaviors. Such ideas have already been corroborated by a number of previous studies (for meta-analyses, see O'Keefe & Jensen, 2007, 2008).

4.3. Limitations and perspectives

These ideas should be taken with caution considering the present study's limitations. First, generalizability issues can be identified. The size of our sample, albeit based on statistical power analyses, could be perceived as relatively small. Furthermore, our sample was mainly composed of French female participants. Importantly, to the best of our knowledge, no theoretical arguments suggest that our variables of interest display different relationships according to gender and culture. However, future studies with more balanced gender ratios, more diverse cultural backgrounds, and greater sample sizes would help establish the robustness of our findings. More broadly, replication

studies featuring a more random sampling process and a preregistered set of decisions about sampling and analyses would be valuable.

Second, measurement issues can be highlighted. In particular, our use of self-report assessment tools is debatable. Importantly, evidence supporting the validity of the tools that we used can be found in the literature (Hogg et al., 2021; Markle, 2013; Moussaoui et al., 2016; Plaisant et al., 2010). Nevertheless, it is conceivable that some of individuals' judgments about their own emotions, behaviors and personality depart from reality. Scenarios in which this departure from reality explains our results are even conceivable. For instance, due to social desirability mechanisms, highly eco-anxious individuals at t1 may have felt pressured to report enhanced pro-environmental behaviors at t2 because their high eco-anxiety at t1 would have been judged to be meaningless otherwise. Thus, in future research, it is important to combine self-report measures with other-reported and/or behavioral measures to establish the robustness of our findings. Another measurement issue with the assessment tool for pro-environmental behaviors that we used is that it does not contain subscales that can easily facilitate a deeper analysis of eco-anxiety's effects. For instance, some theoreticians have suggested that the function of anxiety is mainly evident at the group level (Ein-Dor & Hirschberger, 2018). More precisely, anxious individuals are supposed to act in groups as *sentinels* insofar as they (1) perceive threats before others and (2) share their worries with others in a manner that triggers group-level problem-solving behaviors (Ein-Dor & Hirschberger, 2018). Therefore, a distinction between private and public pro-environmental behaviors could be of interest. However, to our knowledge, this distinction has not been a core component of any tool designed to assess pro-environmental behaviors.

Third, the scope of our hypotheses can be viewed as too narrow. To our knowledge, the present study represents the first longitudinal study pertaining to the effect of eco-anxiety on pro-environmental behaviors. For this reason, we wished to identify the shape of the average effect before examining more complex phenomena in the future. Nevertheless, several studies suggest that individual (e.g., trait anxiety) and contextual (e.g., threat controllability) variables can moderate the

effect of anxiety on problem-solving behaviors. The precise mechanisms that mediate this effect (e.g., the desire to stop feeling painful emotions, energy, vigilance, need for gathering information) also must be identified. Therefore, future studies are needed to understand the contexts in which eco-anxiety motivates pro-environmental behaviors and the contexts in which it does not as well as the mechanisms responsible for these effects. In addition, we analyzed only problem solving as a way of reacting to eco-anxiety. This choice neglected the myriad of other ways of reacting to negative emotions that have been identified in emotion regulation research (Naragon-Gainey et al., 2017; Skinner et al., 2003). This neglect is nonnegligible, as these alternative emotion regulation strategies (e.g., avoidance) may have explained a part of the dropout that we observed (e.g., individuals with high levels of avoidance might have been more inclined to quit the study). Therefore, future studies may attempt to assess a more exhaustive set of ways of reacting to eco-anxiety. This task could be accomplished simply by modifying the instructions of common emotion regulation questionnaires (Baumstarck et al., 2017; Garnefski & Kraaij, 2006) in a manner similar to the *Hogg Eco-Anxiety Scale* (Hogg et al., 2021), which was adapted from a common anxiety scale by changing the instructions to address environmental issues. Finally, studying the lagged effect of anxiety on other problem-solving behaviors in social (e.g., helping people in need) or nonsocial (e.g., studying in preparation for an upcoming exam) contexts could be of interest, as longitudinal studies are lacking in the literature on a number of topics.

Fourth, the number of time points and the interval between them can be debated. A two-wave study possesses feasibility-related advantages over the possible alternatives. In addition, it places a weaker burden on participants. These advantages are why we decided to conduct such a study. Nevertheless, a two-wave study also possesses one major disadvantage with regard to the possible alternatives. Such a study focuses on the between-individual level. For instance, our study suggests that individuals who displayed more eco-anxiety than others at one time point increased their subsequent engagement in pro-environmental behaviors more than others. Therefore, such a study is unable to differentiate within-individual (i.e., state-like) effects from between-individual (i.e., trait-

like) effects. However, it has been widely recognized that effects observed at different levels tend to differ from each other (Borsboom et al., 2009), including effects related to anxiety (e.g., Meissel & Salthouse, 2016). For instance, whereas trait anxiety appears to be negatively related to performance with regard to cognitive tasks, state anxiety seems to exhibit an overall negligible relationship with performance in this context, which actually depends strongly on individual or situational factors (Eysenck, 2023; Meissel & Salthouse, 2016). Moreover, by studying only one time interval (i.e., a 1-month interval), we were unable to determine whether eco-anxiety's effect on subsequent pro-environmental behaviors is mainly due to long-term phenomena (e.g., those lasting months) or short-term phenomena (e.g., those lasting weeks or days). For instance, the eco-anxiety felt at one time may actually foster the eco-anxiety felt 3 weeks later. The eco-anxiety that is felt 3 weeks later may be the main cause of the pro-environmental behaviors performed one month after the initial time point. To address both issues (i.e., the state vs. trait distinction and the appropriate time intervals), future studies with more time points and varied time intervals should be conducted. In particular, intensive longitudinal studies (e.g., daily diaries, experience sampling studies) would be valuable with regard to determining whether the effects that we identified over a 1-month period resemble the effects that could be identified over periods as brief as hours or days.

4.4. Conclusion

The results of the present study confirm that eco-anxiety motivates pro-environmental behaviors. The higher individuals' level of eco-anxiety is at a given time, the greater individuals' tendency is to increase their pro-environmental behaviors in the following weeks. This positive relationship was observed even when possible confounding variables (i.e., ecological identity, the Big Five domains of personality) were controlled for. Future studies are required to identify the variables that can moderate or mediate this relationship.

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Table 1

Descriptive Statistics and Intercorrelations for the Variables of Interest

Variable	1	2	3	4	5	6	7	8	9	10
1. EA t1										
2. EA t2	0.81									
3. PEB t1	0.29	0.31								
4. PEB t2	0.33	0.38	0.83							
5. EI t1	0.25	0.28	0.57	0.50						
6. N t1	0.40	0.45	-0.10	-0.09	-0.02					
7. E t1	-0.15	-0.24	0.04	0.02	-0.01	-0.27				
8. O t1	0.06	0.06	0.20	0.10	0.16	-0.05	0.22			
9. A t1	-0.19	-0.19	-0.02	-0.02	0.00	-0.30	0.02	-0.03		
10. C t1	-0.28	-0.32	0.08	0.10	-0.02	-0.31	0.31	0.13	0.18	
M	1.97	1.83	3.34	3.13	5.39	3.01	3.24	3.74	4.04	3.68
SD	0.52	0.52	0.58	0.56	0.61	1.00	0.87	0.66	0.53	0.68
Skew.	0.31	0.30	-0.25	0.09	-0.15	-0.19	-0.07	-0.66	-0.82	-0.40

Note. M: mean; SD: standard deviation; Skew: skewness; EA: eco-anxiety; PEB: pro-environmental

behaviors; EI: ecological identity; N: neuroticism; E: extraversion; O: openness/intellect; A:

agreeableness; C: conscientiousness. With a threshold set at $p < 0.05$, correlations were statistically

significant when they exceeded the absolute value of 0.14.

Table 2

Pro-environmental behaviors at t2 regressed on eco-anxiety at t1 while controlling for pro-environmental behaviors at t1 and other possible confounding variables.

Predictor	Model 1 (with CV)			Model 2 (without CV)		
	B	SE	<i>p</i>	B	SE	<i>p</i>
(Intercept)	0.011	0.044	0.802	0.010	0.044	0.817
EA t1	0.153	0.051	0.004	0.108	0.045	0.019
PEB t1	0.772	0.054	< 0.001	0.800	0.045	< 0.001
EA t1 * PEB t1	-0.039	0.043	0.366	-0.036	0.042	0.400
EI t1	0.034	0.052	0.518			
N t1	-0.053	0.051	0.304			
E t1	-0.011	0.047	0.822			
O t1	-0.080	0.045	0.075			
A t1	-0.003	0.045	0.940			
C t1	0.078	0.048	0.103			

Note. CV: possible confounding variables; SE: standard error; EA: eco-anxiety; PEB: pro-environmental behaviors; EI: ecological identity; N: neuroticism; E: extraversion; O: openness/intellect; A: agreeableness; C: conscientiousness. Statistically significant relationships are in bold.

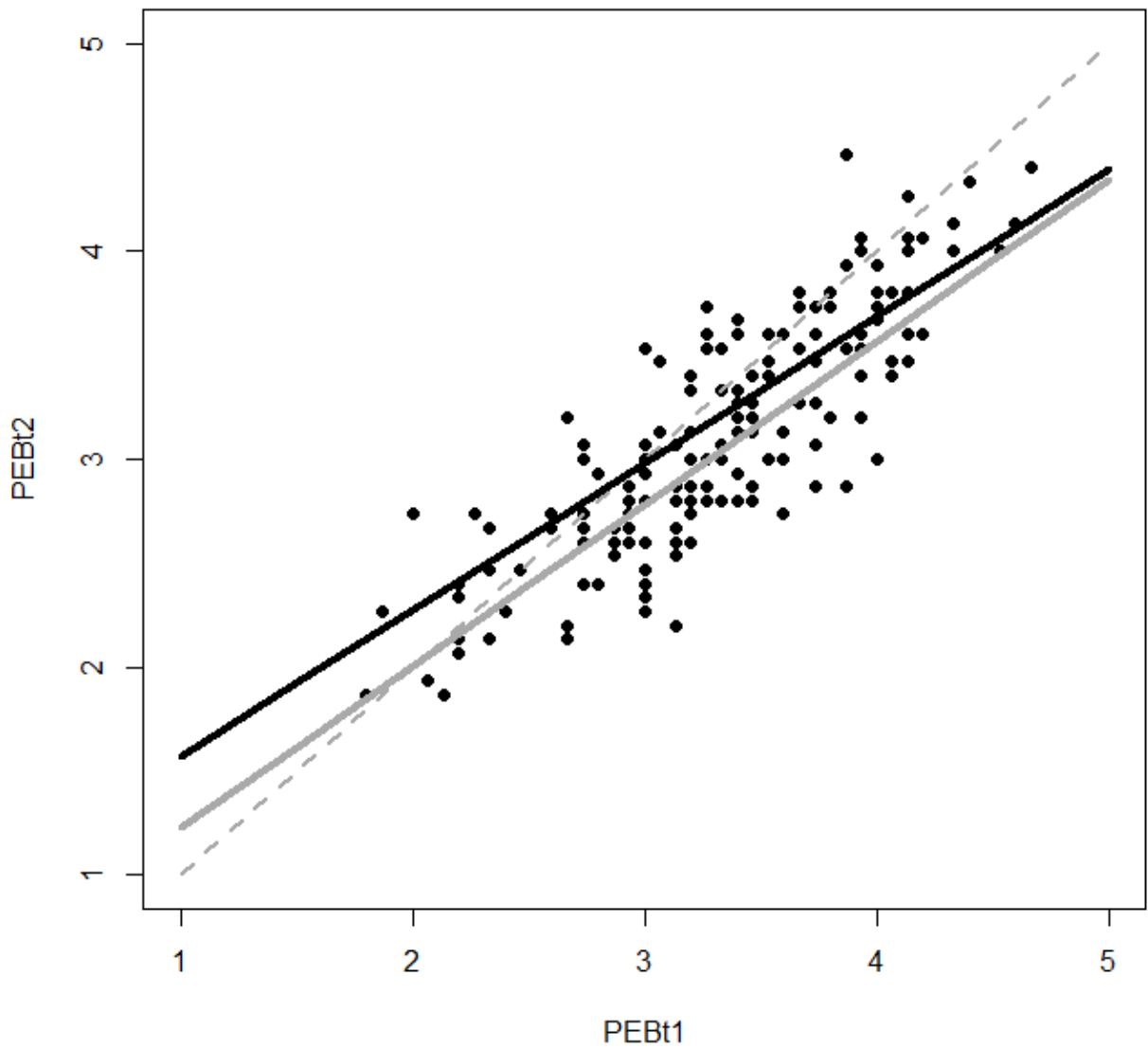


Figure 1

Graphical representation of the prospective effect of eco-anxiety on pro-environmental behaviors.

Note. PEB: pro-environmental behaviors. The dashed gray line represents what would have appeared if individuals had experienced no change in pro-environmental behaviors from t1 to t2. Points below this diagonal are individuals who showed a reduction in their pro-environmental behaviors from t1 to t2. Points above this diagonal are individuals who showed an increase in their pro-environmental behaviors from t1 to t2. The continuous gray line represents individuals with low

eco-anxiety at t1 (i.e., -1 SD), while the continuous black line represents individuals with high eco-anxiety at t2 (i.e., +1 SD).