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From forest immersion to sustainable choices: a systematic approach to the impact of nature exposure on behaviour

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HIGHLIGHTS

- Real forest is more effective than images or VR in promoting sustainable behaviour.
- The natural environment plays a role in encouraging consumers to buy sustainable products.
- VR yields results that are intermediate, lying between the real forest and simple pictures.

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ABSTRACT

The urgency of reducing the environmental impact of food production necessitates innovative approaches to promote sustainable consumer choices. This study investigates how varying levels of interaction with natural environments influence consumer's connection to nature and their preferences for products with sustainable attributes. Using the forest as a representative natural environment, German consumers (n = 210) were exposed to either a real forest immersion, static images of the forest, a virtual reality video of a forest, or memory-based recall before completing a questionnaire and a discrete choice experiment focused on a model sustainable food product: organic honey.

The findings reveal that direct interaction with the forest significantly increased willingness to pay for sustainably produced goods, such as organic products, while virtual reality occupied an intermediate position between visual and real-life experiences. The study highlights the potential of integrating a sense of connection to nature to foster more sustainable consumer behaviour, with implications for environmental policy and marketing strategies.

1. Introduction

The urgent need to mitigate the environmental impact of food systems is becoming increasingly clear (Cooreman-Algoed et al., 2022; Feliciano et al., 2022). While innovation in sustainable food production remains a priority (Kumar et al., 2024), growing attention is being paid to how consumers engage with sustainability (Fantechi et al., 2025). As global food demand continues to rise (Manzoor et al., 2024), influencing consumption patterns becomes as critical as transforming production systems. This shift, from supply to participation, highlights the importance of understanding the psychological mechanisms that underpin sustainable decision-making (Dominici et al., 2024; Pang and Chen, 2024).

Efforts to encourage sustainable choices have mainly relied on cognitive or informational strategies, such as eco-labelling (Zanchini et al., 2025; Saraiva et al., 2021), certification schemes (Piracci et al., 2024), and awareness campaigns (Schütz et al., 2023). While these tools can be effective, they often fail to engage consumers emotionally or experientially (de Kervenoael et al., 2024). Despite the wider availability of green products, many consumers remain disengaged from sustainability initiatives (Fantechi et al., 2024; Yue et al., 2024). This calls for alternative approaches that address deeper motivational and

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relational aspects of consumer behaviour. Among these, the Connectedness to Nature Theory (CNT) provides a valuable framework to understand how affective and experiential relationships with the natural world can serve as psychological antecedents to pro-environmental choices. CNT suggests that individuals who feel emotionally and cognitively integrated with nature develop broader biospheric concerns and are more likely to align their behaviours with environmental values (Schultz, 2000; Mayer and Frantz, 2004).

In this context, the human relationship with nature emerges as a promising, yet underutilised, pathway to sustainability. Research indicates that disconnection from nature is a significant factor contributing to the current environmental crisis, while a renewed sense of connection can foster pro-environmental behaviour and strengthen ecological values (Ives et al., 2018). Moreover, engagement with nature has been shown to enhance individuals' quality of life (Giannico et al., 2021). Contact with natural environments is associated with psychological and physiological benefits (Jeong and Kim, 2024; Redondo et al., 2022) as well as with increased environmental concern and a greater willingness to take action (Whitburn et al., 2020).

However, the ways in which people connect with nature vary widely, from full physical immersion in natural settings to symbolic or mediated experiences, such as photographs, videos, or memory-based recall of past nature experiences. Emerging evidence suggests that even indirect forms of exposure, including virtual representations, can evoke emotional and behavioural responses comparable to those elicited by real environments (Spano et al., 2023; Mattila et al., 2020). Virtual reality, in particular, has been shown to enhance environmental concern by increasing the sense of presence and empathy towards nature (Meijers et al., 2022; Ahn et al., 2016). The degree of immersion appears to play a critical role in shaping engagement: more physically immersive experiences tend to activate affective and sensory systems more fully, potentially leading to deeper and more enduring shifts in values and behaviour, including sustainable consumption.

Despite these promising insights, there is limited understanding of how different types of nature experiences, varying in modality and depth, compare in their capacity to influence actual consumer behaviour. To address this gap, the present study compares four distinct modes of engaging with nature — memory-based recall, static images, virtual reality, and physical immersion in a forest — and evaluates their effects on individuals' psychological connection to nature and their willingness to pay (WTP) for an organic food product (honey). To capture both psychological and behavioural shifts, the study integrates psychographic assessments and a discrete choice experiment (DCE) as a behavioural outcome measure and proxy for real-life consumer decisions.

The novelty of this work lies in its integrated design, which empirically maps a gradient of sensory immersion and connects short-term psychological shifts to actual behavioural responses. Our contribution is twofold: we provide empirical evidence on how varying degrees of immersion shape sustainable consumer behaviour, and we advance a conceptual view of nature as a relational and psychological stimulus capable of reshaping values and decisions.

2. Literature review

A growing body of research has demonstrated that interaction with nature can positively influence sustainable behaviours. For instance, Jeong and Kim (2024) found that contact with natural environments improves individuals' well-being, while Redondo et al. (2022) showed that it enhances ecological awareness. Furthermore, Giannico et al. (2021) highlighted that such contact fosters values supportive of sustainability, a finding supported by Ives et al. (2018), who linked disconnection from nature to environmental degradation. These effects appear particularly relevant for younger generations; Jeong and Kim (2024) and Somad et al. (2024) both report a strong correlation between connectedness to nature and sustainable purchasing preferences among Generation Z.

Meta-analytic evidence robustly supports a positive association between psychological connection to nature and pro-environmental behaviour (Whitburn et al., 2020). This connection is not merely cognitive, but also deeply emotional. Dong et al. (2020) demonstrated that emotional bonds such as love and passion for nature mediate moral concern, which in turn motivates sustainable actions. Similar findings were reported by Wu and Zhu (2021), who showed that intimacy with nature is a predictor of environmentally responsible behaviour. Elsotouhy et al., 2025 further emphasized these affective dimensions as critical drivers of green purchasing. Complementing these emotional factors, Jaiswal and Bihari (2020), Gkargkavouzi et al. (2019), and Kautish et al. (2021) found that affective engagement predicts green consumption patterns.

Attitudes and perceived responsibility towards the environment also play an essential role. Sun and Wu (2023) identified a consistent link between positive environmental attitudes and pro-environmental behaviour, a relationship also evidenced by Paswan et al. (2017). Jansson et al. (2010) and Werner and Risius (2021) suggest that a sense of personal responsibility amplifies these effects. This indicates that both rational awareness and affective engagement jointly foster sustainable behaviour.

Various experimental tools have been explored with the aim of evoking and strengthening connection to nature. Virtual reality (VR) has shown particular promise in increasing ecological concern. Leung et al. (2022) found that immersive virtual nature experiences enhance feelings of connectedness, while Nurlatifah et al. (2023) showed VR can increase empathy towards non-human life. Similarly, Plechatá et al. (2024) demonstrated that such experiences translate into higher pro-environmental intentions. Smit et al. (2021) used VR supermarket simulations effectively to encourage sustainable food choices in children, highlighting potential for early behavioural interventions.

Visual and auditory stimuli of nature have also been leveraged to influence consumer preferences. Zhao et al. (2025) found that photographs of natural landscapes nudged consumers toward sustainable products, while Spendrup et al. (2016) reported that natural sounds can enhance the perceived value of green goods. These sensory cues can be integrated into marketing and education strategies to subtly promote sustainability.

Interactive methods such as pop-up messages and immersive scenarios have been shown to prompt reflection on the impacts of consumption. Meijers et al. (2022) and Smit et al. (2021) demonstrated that such approaches increase experiential learning and emotional engagement, leading to more durable behavioural change. This is consistent with the theoretical proposition of CNT, which holds that emotional and sensory immersion fosters a sense of inclusion of nature in the self (Schultz, 2002). This inclusion expands the moral circle to encompass non-human life (Clayton and Opotow, 2003) and situates environmental concern within a relational framework linking experiential contact with nature to behavioural outcomes (Beery and Wolf-Watz, 2014).

Empirical studies by Gosling and Williams (2010) and Shimul et al. (2024) have shown that connectedness to nature mediates the relationship between environmental knowledge and sustainable behavioural intentions, further supporting its role as a key motivational factor.

Despite growing recognition of nature's role in shaping pro-environmental attitudes and behaviours, existing research rarely compares different types of nature experiences in terms of their impact on actual consumer decisions. Most studies focus on attitudinal or descriptive outcomes, without systematically examining how variations in sensory richness and immersion affect behavioural intentions such as willingness to pay for sustainable products.

This study addresses these gaps by integrating findings from environmental psychology, behavioural science, and sensory design to assess how different modes of nature engagement influence both psychological connection and sustainable consumption. To our knowledge, no previous work has systematically compared multiple levels of sensory immersion—from memory-based recall and static images to virtual

reality and real forest exposure—within a single experimental design. By linking these graded experiences to both attitudinal and behavioural outcomes, the study contributes to a more nuanced understanding of how the intensity and modality of nature contact shape sustainable consumption. In doing so, it advances theoretical understanding of the human–nature relationship and offers practical insights for promoting environmentally responsible consumer behaviour through experiential interventions.

3. Methodology

3.1. Overview

This study employed a mixed experimental design combining between- and within-subjects elements. Participants were randomly assigned to one of four groups representing different levels of nature exposure (between-subjects). To assess psychological changes resulting from the treatments, key psychographic variables were measured both before and after the intervention (within-subjects). Behavioural preferences were captured through a discrete choice experiment (DCE), a widely used method for estimating willingness to pay and evaluating consumer decision-making in sustainability contexts. This combined approach allowed us to analyse both between-group differences and within-individual changes resulting from varying levels of sensory and emotional immersion. In this framework, psychographic variables were used to detect attitudinal shifts, while the DCE offered a behavioural readout of whether and how those shifts translated into actual consumer preferences.

3.2. Ethics statement

Participation in the study was entirely voluntary, and all participants were thoroughly informed about the experimental setup beforehand. They provided written consent prior to participation. Participants retained the right to withdraw from the study at any time without needing to provide a reason.

Upon completing the experiment, each participant was compensated with an expense allowance of €10. The study adhered to the ethical guidelines outlined by the American Psychological Association (APA) and complied with the Declaration of Helsinki. The procedure received prior approval from the university's ethics committee.

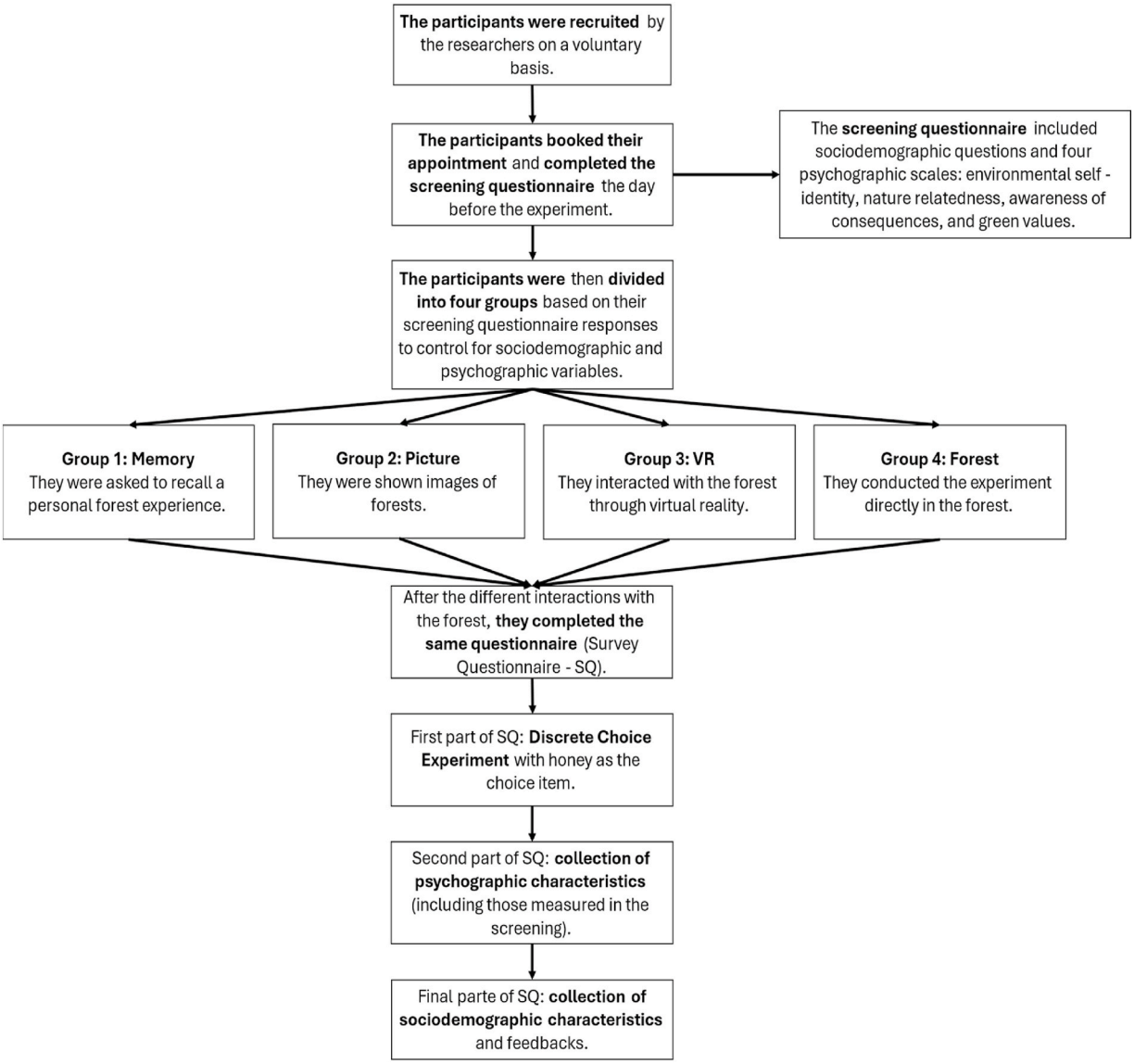

Fig. 1. Procedure of the experiment (n = 210 participants).

3.3. Study design and exposure conditions

For clarity, Fig. 1 shows all the steps of our experiment, which will be described in detail in the following paragraphs.

To examine how varying levels of exposure to natural environments influence sustainable choices, we designed an experiment with a sample of German consumers. Building on the premise outlined in the introduction that a connection to nature positively affects sustainability-oriented behaviours, we selected a forest as the natural setting for the study. Forests were chosen because, despite being managed by humans, they are commonly perceived as quintessential natural environments (Upadhyay and Singh, 2024; Zhao et al., 2020). Moreover, Germany is home to a significant number of forested areas, and most individuals have a forest located relatively close to where they live, making it an accessible and relevant context for the participants.

Participants were randomly assigned to one of four treatment groups, each exposed to the forest in a different format, ordered according to increasing levels of sensory immersion:

Group 1: Memory – recall of a personal forest experience.

Group 2: Pictures – static images of a forest shown on screen.

Group 3: VR – 360° virtual reality video of a forest.

Group 4: Forest – physical immersion in a real forest environment.

These groups were designed to represent a gradient of experiential richness, from symbolic to fully embodied nature exposure. Detailed descriptions of each condition are provided in the following section (*Stimuli Design*).

After engaging with the forest in different ways, all participants completed the same empirical study assessment via questionnaire, described in more detail in the following section. To explore how varying levels of interaction with nature influenced preferences for sustainable purchases, we employed a discrete choice experiment (DCE). This methodology was selected for its straightforward application and the ease with which its results could be interpreted for our study.

To assign participants to one of the four groups, all participants completed a screening questionnaire during the two days leading up to the experiment. The screening included a psychographic empirical assessment designed to: 1) evaluate their previous forest experiences and 2) to assess and control for interaction effects between the forest experience and the subsequent choice experiment.

Since the primary aim of the study was not to analyse the choice experiment per se, but rather to use it as a proxy for behavioural outcomes following different levels of nature exposure, four psychographic variables—environmental self-identity, nature relatedness, awareness of consequences, and green values—were measured. These variables allowed us to evaluate the impact of the forest experience independently of the DCE and to account for individual characteristics that might explain variation in responses to forest exposure.

To ensure comparability, participants were assigned to the groups based on their screening results, such that there were no significant a priori differences in psychographic characteristics or gender.

The secondary aim was to evaluate the specific effect of the forest experience by re-administering the same psychographic scales on the day of the experiment. This repeated-measures design enabled within-subject comparison of participants' responses before and after exposure across all groups. By analysing these pre–post differences, we were able to assess how each level of exposure—from memory-based recall to real forest immersion—affected changes in key psychographic indicators, such as environmental self-identity, nature relatedness, awareness of consequences, and green values.

3.4. Stimuli Design

To reflect different levels of forest exposure, the following materials were used:

Group 1 "Memory" was asked to recall their last visit to a forest before completing the questionnaire. This brief recollection was intended to activate a general forest-related context without providing any visual or auditory stimuli. Although this task involved a minimal level of engagement, it created a shared cognitive frame for all participants, allowing comparison with progressively more immersive conditions (Picture, VR, and Forest). The "Memory" group therefore represents the lowest level of forest exposure in our design, serving as the reference condition for evaluating the incremental effects of sensory and emotional immersion.

Group 2 "Pictures" was shown four images within the online questionnaire, with each image displayed for at least 30 s. The four forest images used are shown in Fig.2.

Group 3 "VR" experienced a 5-min, 360-degree virtual reality video that fully immersed them in a forest environment, including ambient forest sounds. The video, which is freely available on YouTube and was not developed specifically for this study, can be viewed at the following link: https://www.youtube.com/watch?v=o_r5y6Ug8eY&t=223s. Consent was obtained from the video producer prior to use. A screenshot from the video is shown in Fig. 3.

While the video did not allow for interactivity, it was selected for its high visual realism and ecological validity, aligning with key VR design principles that emphasise presence and immersion through audiovisual fidelity (Taufik et al., 2021). Participants were free to look around using a head-mounted display while seated in a swivel chair or standing, enhancing their sense of agency within the virtual space. Although some design principles, such as interactivity, were not implemented—primarily to maintain comparability with the static image and memory groups—prior research suggests that even passive VR exposure can increase connectedness to nature and pro-environmental intentions (Leung et al., 2022; Brambilla et al., 2024).

Group 4 "Forest" spent 5 min immersed in a real forest environment. The forest was located near the centre of the German city of Göttingen (51.535548, 9.956695; Göttingen, Germany), where the study took place. Fig. 4 shows the location used for this condition.

3.5. Data collection procedure

The experiment was conducted in March 2024 at the University of Göttingen (Groups 1–3, in a laboratory setting) and in an adjacent forest (group 4). Participants were recruited through an online announcement on the university's student job portal and social media channels, the distribution of flyers, and direct contact on campus. After booking an appointment and completing a screening questionnaire, participants were assigned to one of the four groups.

Participants in the "Memory", "Picture" and "VR" groups were invited to the University of Göttingen to take part in the experiment in a seminar room, while the "Forest" group was directed to the outdoor location of the experiment based on the coordinates provided.

At the study site, participants in the "Memory", "Picture" and "VR" groups were welcomed by a member of the research team who introduced them to the experiment. For the "Memory" and "Picture" groups, participants completed the experiment in an isolated room using a computer set up by the team. The images and instructions were part of their online questionnaire.

For the "VR" group, participants were taken to a separate room, where another researcher explained how to use the headset, provided instructions on interacting with the video, and clarified that the video interaction would last 5 min, after which participants would complete the questionnaire. Fig. 5 shows a participant using the headset during the experiment. Participants could choose to stand or sit in a swivel chair, depending on their preference and comfort.

Participants in the "Forest" group were invited by a researcher to sit on a bench and spend 5 min immersed in the forest environment. Afterwards, they were asked to complete the questionnaire in paper format. The benches allowed participants to relax both during the forest exposure and while completing the approximately 20-min questionnaire. Multiple benches at the experiment site enabled several

Fig. 2. Four example images shown to the Picture group.

Fig. 3. A frame from the virtual reality video shown to the VR group. Note: This is a screenshot of the 360-degree video used for this study. The video is publicly available on Youtube: https://www.youtube.com/watch?v=o_r5y6Ug8eY&t=223s.

Fig. 4. A view of the environment where the forest experiment took place, with a participant engaged in the experiment.

participants to take part simultaneously, whereas laboratory sessions were conducted individually. Participants were instructed not to talk, use their phones, or read, and simply to be present in the moment.

3.6. The questionnaire and the DCE

The DCE involved a food choice task in which participants were asked to imagine choosing between two similar products, each differing in a limited number of attributes. The discrete choice experiment was employed as an integrated behavioural component of the experimental protocol, designed to assess how nature exposure might translate into concrete sustainability-related consumer decisions. Participants could select one of the two products or, if neither was satisfactory, opt for a "No choice" option. Honey was chosen as the focal product for the DCE, as it is widely consumed in Germany (Bissinger and Herrmann, 2021) and commonly associated with naturalness (Nascimento et al., 2022). The experimental design was intentionally kept simple. The attributes included only price—set at three levels based on market research (€7, €11, and €14)—and the presence or absence of organic certification,

Fig. 5. A participant from the "VR" group during the experiment.

Table 1
Attributes and their respective levels of the Discrete Choice Experiment.

Attribute	Level
Price	7 € 11 € 14 €
Organic label	Present Absent

which represented a sustainability attribute (Table 1). Organic certification was selected for its wide recognition in the market and its established influence on consumer behaviour as a sustainability indicator (Sica and Franco, 2024; Saraiva et al., 2021). In addition, honey is a product well suited to organic production (Murmura et al., 2024), making the scenario realistic.

This streamlined design focused attention on the sustainability attribute while keeping the number of choice sets manageable, thus minimising participant fatigue. The experiment included six purchase scenarios, based on an orthogonal design generated using Ngene software (v1.3.0). Fig. 6 provides an example of a choice set from the questionnaire, featuring a 500-g jar of honey produced in Germany as the reference product.

Participants also answered questions about the frequency of their honey consumption, organic purchases, and visits to forests and parks.

Next, psychographic characteristics were measured using validated scales identified in the literature as predictors of sustainable behaviour. Specifically, we used *environmental self-identity*, which has been shown

Fig. 6. Example of a choice set from the experiment.

to predict organic consumption (Qasim et al., 2019) and sustainable food behaviour more broadly (Gravelines et al., 2022). *Nature relatedness,* the second scale applied, has been found to explain a positive attitude towards sustainable nutrition (Weber et al., 2020) and predict ecologically sustainable behaviours (Folwarczny et al., 2023). Moreover, a review of the literature has revealed that *awareness of the consequences* of unsustainable behaviours, i.e., the third scale, improves individuals' actions in that regard (Gunawan et al., 2024; Gómez-Llanos et al., 2020; Hörisch et al., 2020). Similarly to awareness, we also used the *green scale*, which measures consumers' green values (Xara-Brasil et al., 2023).

These scales were used both to screen participants (see above) and as attitudinal measures in the experimental phase, meaning they appeared in both the screening and post-exposure questionnaires.

Additional variables were collected only in the experiment-day questionnaire: consideration of future consequences, due to its role in sustainable food choices (Tuu and Khoi, 2024), and involvement in sustainable eating (Boncinelli et al., 2023; Contini et al., 2023). Lastly, like awareness of consequences, we measured personal norms and ascription of responsibility with regard to sustainability, both part of the Norm Activation Model for predicting behaviour (Schwartz, 1977).

We also measured participants' involvement with the product as a control variable that could influence preferences independently of the forest experience. Additionally, we assessed their sense of spatial presence in the forest, both in terms of location and action, to assess whether the experiment had the intended effect on participants.

Finally, the last section of the questionnaire gathered sociodemographic data, including gender, age, professional qualifications, income, household size, number of children, and diet. Furthermore, an open-ended section allowed participants to provide feedback on the experience, which helped us interpret and discuss some of the findings.

3.7. Analysis framework

Table 2 presents all the psychographic scales used, along with their respective items and sources. All 11 variables listed in the table were analysed using a MANOVA model to assess whether differences existed between the four groups. Following this, one-way ANOVA was conducted for each variable, with the Bonferroni test applied to account for multiple pairwise comparisons.

In addition to these 11 variables, differences between the screening and the questionnaire were also examined for environmental self-identity, nature relatedness, green scale, and awareness of consequences. This allowed us to assess whether these traits changed as a result of exposure to the forest stimuli. We also tested differences in the change scores across the four groups for the same scales measured in the screening questionnaire and those measured on the day of the experiment.

3.8. Discrete choice experiment

From an econometric standpoint, the theoretical foundations of DCE can be traced to Lancaster's work on consumer behaviour (1966) and the Random Utility Theory formulated by McFadden (1972). Lancaster posited that a consumer's utility from a product is the sum of its attributes, while McFadden highlighted that a rational consumer will choose the option offering the greatest utility among available alternatives.

These principles imply that in a discrete choice context, the likelihood of a consumer selecting a given alternative depends on the relative utility compared to other options (Train, 2009). Equation (1) presents the classical definition of utility derived from this theory.

$$U_{ijk} = \boldsymbol{\beta}' \boldsymbol{X}_{ijk} + ASC + \varepsilon_{ijk} \quad \text{(Equation 1)}$$

In the equation, U denotes the utility that consumer i derives in choice context k by selecting option j. $\boldsymbol{\beta}'$ is a vector of coefficients reflecting the weights assigned to each level (X_{ijk}) of the attributes (i.e.,

Table 2
Items of the scales used and their statistics.

Scale	Item	Average	Standard Deviation	Source
Environmental self-identity	Acting environmentally friendly is an important part of who I am	4.80	1.21	Van der Werff et al. (2013)
	I am the type of person who acts environmentally friendly	4.90	1.10	
	I see myself as an environmentally friendly person	5.00	1.11	
	I don't care about the environment (R)	1.42	0.73	
Nature relatedness	My ideal vacation spot would be a remote, wilderness area	4.10	1.87	Nisbet and Zelenski (2013)
	I always think about how my actions affect the environment	4.40	1.31	
	My connection to nature and the environment is a part of my spirituality	3.30	1.71	
	I take notice of wildlife wherever I am	4.90	1.56	
	My relationship to nature is an important part of who I am	4.55	1.48	
	I feel very connected to all living things and the earth	4.11	1.50	
Awareness of consequences	My purchasing choices also have an impact on climate change	5.43	1.44	Schwartz (1977)
	My purchasing choices also have an impact on biodiversity	5.26	1.44	
	If everybody made ethical choices the food market would orient itself accordingly	5.67	1.42	
Green scale	It is important to me that the products I use do not harm the environment	5.03	1.08	Haws et al. (2014)
	I consider the potential environmental impact of my actions when making many of my decisions	4.78	1.26	
	My purchase habits are affected by my concern for our environment	4.80	1.25	
	I am concerned about wasting the resources of our planet	6.04	1.10	
	I would describe myself as environmentally responsible	5.00	1.16	
	I am willing to be inconvenienced in order to take actions that are more environmentally friendly	4.90	1.23	
Consideration of future consequences	My present behaviour is affected by the results I will receive in the future	6.22	0.80	Olsen and Tuu (2017)
	When deciding to consume food products I often think about how they will affect me in the future	5.12	1.22	
	I prioritise using food products that will be better for me in the future rather than those that provide me with immediate results	4.96	1.35	
	I often think about the future negative consequences of the food I am currently consuming, even though negative outcomes will not occur for many years	4.60	1.51	
Involvement in sustainable eating	Sustainable eating is very important to me	4.90	1.20	Pieniak et al., 2010
	I care a lot about sustainable eating	4.89	1.24	
	Sustainable eating means a lot to me	4.78	1.28	
	I am very concerned about the consequences of what I eat in terms of sustainability	4.49	1.35	
	I don't have time to consider sustainability in relation to my diet (R)	2.68	1.42	
	When I eat, I'm not interested in sustainability (R)	2.69	1.30	
Personal norm	I feel a moral obligation to protect the environment	5.54	1.29	Onwezen et al. (2013)
	I feel that I should protect the environment	6.09	0.88	
	I feel it is important that people in general protect the environment	6.41	0.80	
	Because of my own values/principles, I feel an obligation to behave in an environmentally friendly way	5.63	1.11	
	I don't care about the environment (R)	1.50	0.86	

(continued on next page)

Table 2 (*continued*)

Scale	Item	Average	Standard Deviation	Source
	The environment does not need my support (R)	2.02	1.21	
Ascription of responsibility	I feel personally responsible for the problems resulting from my non-ecofriendly product purchases	4.43	1.52	Abrahamse et al. (2009); Abrahamse and Steg (2011)
	My non-ecofriendly purchases contribute to environmental problems	5.26	1.37	
	I take joint responsibility for environmental problems	5.25	1.30	
Product involvement	I have a strong interest in honey	5.48	1.46	Mittal and Lee (1989)
	Honey is very important to me	3.19	1.62	
	For me honey does not matter (R)	4.33	1.89	
Spatial presence (location)	I felt like I was actually in the forest	4.01	1.81	Hartmann et al. (2015)
	I have lost track of time	4.03	1.76	
	It seemed as though I actually took part in the action	3.48	1.53	
	It was as though my true location had shifted into the forest	3.55	1.67	
	I felt as though I was physically present in the forest	4.06	1.78	
	The forest gave me the feeling that I could do things with it	3.35	1.53	
Spatial presence (action)	I felt like I could move around among the objects in the forest	3.89	1.68	Hartmann et al. (2015)
	It seemed to me that I could do whatever I wanted in the forest	3.70	1.75	
	I had the impression that I could do anything I wanted in the forest	3.09	1.55	
	I was unaware of my real surroundings	2.54	1.47	
	I had the feeling that I was only perceiving images (R)	3.41	1.82	

Note: All items were measured using Likert scales ranging from 1 (completely disagree) to 7 (completely agree).

price and organic certification) on the utility function. The ASC (Alternative Specific Constant) captures the fixed attributes of the DCE scenario, such as a 500g jar of honey produced in Germany. Lastly, ε_{ijk} is the error term, assumed to be independently and identically distributed.

3.9. Conditional logit model and mixed logit model

For the data analysis, we employed both a conditional logit model and a mixed logit model, commonly used in DCEs (Hauber et al., 2016). In both models, the utility function follows the structure outlined in Equation (1). The conditional logit model is a standard baseline approach and assumes Independence of Irrelevant Alternatives (IIA), meaning the relative odds of choosing between any two alternatives are unaffected by the presence of other available options. However, this assumption may not always hold in practice. To test its validity, we conducted a Hausman test comparing models estimated with and without one alternative, which showed no significant violation of the IIA assumption.

Recognising that preferences are likely to vary among individuals, we further implemented a mixed logit model. This model generalises the conditional logit by allowing coefficients to vary randomly across individuals, thereby capturing unobserved heterogeneity in preferences and relaxing the IIA assumption. Additionally, the mixed logit model enables the estimation of individual-specific willingness to pay (WTP) and facilitates investigation of its relationship with psychographic characteristics through linear regression. To this end, we tested all variables listed in Table 2, along with the frequency of organic product consumption. While this model is not structured as a mediation analysis, it offers valuable insights into how psychological traits relate to behavioural outcomes, supporting an integrative interpretation of the observed effects.

The combined use of both models provides a robust analytical framework, balancing the interpretability of the conditional logit with the flexibility and improved fit of the mixed logit.

All econometric analyses (one-way ANOVA, MANOVA, conditional logit, mixed logit, regression, and their respective reliability indices) were conducted using Stata/SE 18.

4. Results

4.1. Sample characteristics

A total of 210 participants took part in the experiment: 54 in the "Memory" group, 53 in the "Picture" group, 53 in the "VR" group, and 50 in the "Forest" group. The number of participants was determined using an a priori analysis conducted with G*Power 3.1.9.7, setting an effect size of 0.15 (for the MANOVA model with 15 variables), a statistical power of 0.85, and an alpha level of 0.05 (Faul et al., 2009). A small effect size was chosen as a conservative measure, given the limited availability of comparable studies, to detect even minor differences in the questionnaire variables.

Table 3 presents the sociodemographic characteristics of the sample. The four groups did not differ significantly on any of the characteristics examined (gender, age, professional qualification, income, household size, and number of children). The table also includes additional control variables that we monitored for their potential influence on the results, such as diet, frequency of visits to parks and forests, and frequency of honey and organic product consumption. None of these variables differed significantly between the groups, except for the frequency of forest visits, where the "Forest" group reported significantly more frequent visits than the "Picture" group ($p < 0.01$). Therefore, the sample is well-balanced across the groups in terms of both sociodemographic characteristics and behaviours relevant to our study. This well-matched sample across experimental conditions enhances internal validity and ensures that any observed differences can be more confidently attributed to the nature exposure treatments rather than pre-existing disparities.

In addition, the screening enabled us to control for selected psychographic variables in advance. Table 4 shows average scores for environmental self-identity, nature relatedness, the green scale, and awareness of consequences from the screening. None of these characteristics differed significantly between groups prior to the experiment. One-way ANOVA confirmed the absence of significant group differences ($p = 0.22$, $p = 0.36$, $p = 0.35$, $p = 0.58$, respectively).

Table 3
Sociodemographic and behavioural characteristics of the sample (n = 210).

Variable	Memory	Picture	Virtual Reality	Forest	Sample
Gender					
Male	25	19	19	19	82
Female	29	34	34	31	128
Age	26.2	27.8	28.7	27.0	27.4
Professional qualification					
None	27	19	20	28	94
Apprenticeship	2	8	5	5	20
Technical	1	0	1	2	4
University	24	26	27	15	92
Income	1052	1158	1011	1213	1108
Household size	2.63	2.21	2.30	2.44	2.40
Number of children	0.17	0.02	0.02	0.10	0.08
Diet					
Omnivorous	25	21	20	13	79
Flexitarian	12	20	19	17	68
Vegetarian	15	10	9	14	48
Vegan	2	2	5	6	15
Frequency of forest visits					
Less than once a month	21	27	19	16	83
1-4 times a month	31	23	28	22	104
More than once a week	2	3	6	12	23
Frequency of park visits					
Less than once a month	27	26	17	15	85
1-4 times a month	24	24	34	28	110
More than once a week	3	3	2	7	15
Frequency of honey consumption					
Never	10	9	8	8	35
Less than once a month	14	17	20	15	66
1-3 times a month	21	19	13	15	68
Once a week or more	9	8	12	12	41
Frequency of organic consumption					
Never	3	1	1	0	5
Less than once a month	4	1	6	2	13
1-3 times a month	13	10	12	11	46
1-2 times a week	23	35	22	23	103
3 times a week or more	11	6	12	14	43

Table 4
Psychographic characteristics assessed in the screening questionnaire before the day of the experiment, divided by group. None of these differed significantly between groups.

Variable	Memory	Picture	Virtual Reality	Forest
Environmental self-identity	5.62	5.75	5.73	5.98
Nature relatedness	4.25	4.29	4.23	4.53
Awareness of the consequences	5.34	5.32	5.14	5.44
Green scale	5.07	5.19	5.11	5.29

Note: All items were measured using Likert scales ranging from 1 (completely disagree) to 7 (completely agree).

The screening data confirm that the four groups had comparable baseline psychographic profiles. This strengthens the internal validity of the experimental design and supports the interpretation that any post-treatment differences were attributable to the experimental manipulation rather than pre-existing differences.

4.2. One-way ANOVA

The following analyses focus on changes in psychographic variables observed following exposure to the treatments. The MANOVA tests revealed significant group effects across the set of variables examined, with p-values below 0.05 for all multivariate statistics (Wilks' Lambda: $p = 0.0020$, Pillai's Trace: $p = 0.0032$, Lawley-Hotelling: $p = 0.0012$, Roy's Largest Root: $p < 0.0001$), indicating that the groups differed significantly in their psychographic dimensions. Based on these results, we conducted one-way ANOVA for each psychographic variable to identify specific differences. Table 5 presents the overall results of the model, including the means for each group and Cronbach's alpha values. All alpha values exceeded the 0.7 threshold, indicating acceptable internal consistency. We also compared participants' scores before and after the treatment, by analysing changes between the screening phase and the post-treatment phase. This within-subject comparison (deltas in the table) focused on environmental self-identity, nature relatedness, the green scale, and awareness of consequences. These change scores allowed us to detect potential shifts attributable to the exposure condition.

As shown in the table, relatively few differences reached statistical significance. Interestingly, only the "Forest" group exhibited differences from the other groups, while the other three groups did not differ significantly from one another, even in terms of the sense of presence. In contrast, sense of presence (location) was greater in the "Forest" group compared to the "Picture" and "Memory" groups, though not compared to the "VR" group. This aligns with the fact that the video shown via headset closely resembled the real forest, with no distinctions emerging between the two. The pattern was different for the sense of action, where the "Forest" group reasonably differed from all the others. Among the psychographics measured exclusively post-treatment, only the consideration of future consequences differed significantly between the "Forest" and "Memory" groups. A different analysis can be made regarding the characteristics assessed in both questionnaires. In fact, while no significant differences were found in the screening, they became significant for the green scale between the "Forest" and "Picture" groups, and the differences between the post-treatment questionnaire and the screening varied between the "Forest" group and those in the "Picture" and "Memory" groups. This shift implies that the exposure to an actual natural environment may have had a cumulative and latent effect, particularly on values linked to sustainability. While the mean changes were small, their directionality was consistent and suggests a subtle but meaningful realignment of attitudes towards greener behaviour. In addition to the differences in group means, the analysis of standard deviations reveals important patterns. In particular, variables such as spatial presence and consideration of future consequences displayed higher variability in the Forest group, indicating heterogeneous responses to the natural exposure. This variability suggests that while some participants were strongly influenced by the immersive experience, others were less affected. Such differences point to the presence of individual traits or predispositions that moderate the impact of environmental stimuli, offering avenues for future research into psychographic segmentation.

For completeness, within-group t-tests were conducted on the Δ scores to assess whether post-treatment changes were statistically significant within each group. Some variables showed significant changes: nature relatedness decreased significantly in the "Picture" group, environmental self-identity decreased in all groups, and the green scale decreased in the "Picture" group, while all other within-group differences were non-significant ($p > 0.05$). These within-group variations were not the primary focus of the study, as the pre- and post-measures were included mainly to ensure the equivalence of the groups before the experimental manipulation. The observed decreases may reflect well-established psychological mechanisms rather than harmful treatment effects: they could arise from short-term upward-comparison or self-evaluative processes triggered by exposure to idealized visual stimuli (media-based upward comparison can depress state self-evaluation; Vogel et al., 2014), or from normal within-person, short--term fluctuations documented in intensive longitudinal/daily-diary research (Schmid et al., 2024; Richter and Hunecke, 2022; Wright and Simms, 2016).

Table 5
Results of the one-way ANOVA model. Cronbach's alpha, the overall mean, and the standard deviation are reported for each scale.

Variable	Memory	Picture	Virtual Reality	Forest	Δ F-NF	Δ F-P	Δ F-VR	Alpha	Mean	Standard Deviation
Environmental self-identity	5.30	5.28	5.21	5.51				0.86	5.32	0.89
Nature relatedness	4.18	4.13	4.28	4.42				0.81	4.24	1.12
Awareness of the consequences	5.54	5.52	5.28	5.48				0.77	5.45	1.19
Green scale	4.93	5.04	5.03	5.37		*		0.89	5.09	0.95
Δ Environmental self-identity	−0.31	−0.46	−0.52	−0.47						
Δ Nature relatedness	−0.07	−0.15	−0.04	−0.12						
Δ Awareness of consequences	0.20	0.19	0.13	0.04						
Δ Green scale	−0.15	−0.15	−0.08	0.09	*	*				
Consideration of future consequences	4.92	5.27	5.23	5.51	***			0.72	5.23	0.92
Involvement in sustainable eating	4.85	4.94	4.86	5.15				0.90	4.95	1.05
Personal norm	5.98	6.02	5.89	6.23				0.84	6.02	0.77
Ascription of responsibility	4.82	4.98	4.94	5.20				0.81	4.98	1.20
Product involvement	4.05	3.95	4.12	4.34				0.77	4.11	1.39
Spatial presence (location)	3.39	3.30	3.88	4.47	***	***		0.87	3.75	1.32
Spatial presence (action)	3.53	3.08	3.54	4.13	**	***	**	0.72	3.56	1.15

Note. ***p < 0.01; **p < 0.05; *p < 0.1. The columns for Δ P-NF, Δ VR-NF, and Δ VR-P are not reported as no significant differences were observed. The Δ values for the scales are calculated by subtracting the screening values from the questionnaire values. All items were measured using Likert scales ranging from 1 (completely disagree) to 7 (completely agree).

4.3. Logit models

Table 6 presents the results of the conditional logit model. All coefficients were significant across groups. As expected, higher prices reduced product utility, while the presence of organic certification had a significant and positive effect on consumer choices. Differences between group coefficients were modest but meaningful. Specifically, the price coefficient remained consistent across groups. In contrast, the utility coefficient for organic certification was significantly higher in the "Forest" group compared to the "Picture" and "Memory" groups. This finding, together with the ANOVA results, further emphasises the distinctions between these groups. Meanwhile, the "VR" group occupied an intermediate position, showing no significant differences from either the "Forest" group or the "Picture" and "Memory" groups.

We tested the Independence of Irrelevant Alternatives (IIA) assumption for the conditional logit model using a Hausman test, comparing the full model with a reduced model excluding one alternative. The non-significant test result ($\chi^2(3) = 3.68$, $p = 0.2987$) supports the validity of the IIA assumption in our data.

Building on the conditional logit model, which highlighted differences between groups, we implemented a mixed logit model. Insights from the conditional model informed the decision to specify fixed coefficients for price (which remained constant across all consumers, as no group-level differences were observed) and random coefficients for organic certification to account for individual variations. The mixed model demonstrated superior performance compared to the conditional logit model based on model fit indicators (BIC mixed = 1663; BIC conditional = 2923; AIC mixed = 1638; AIC conditional = 2904). Table 7 presents the mixed model results, where all coefficients were statistically significant, consistent with the findings of the conditional model.

Table 7
Mixed logit results.

Attribute	Coefficient	Standard error
Price	−0.51***	0.03
Organic	2.23***	0.29
ASC	5.20***	0.21
SD_Organic	2.32***	0.21

Note. ***p < 0.01.

Notably, the standard deviation of the organic certification coefficient was also significant, confirming the presence of individual-level variability in preferences.

These findings align with the observed variability in psychographic dimensions, particularly in the Forest group, and may help explain the stronger yet heterogeneous response to organic certification in this group. The presence of individual-level differences, captured in the mixed logit model through the random coefficient for organic, reinforces this interpretation.

To test the assumptions of the ordinary least squares (OLS) regression, we examined the residuals for normality and homoscedasticity. The Shapiro–Wilk test indicated a mild departure from normality ($p = 0.037$). To assess the functional form of the dependent variable, a Box–Cox transformation was applied. The estimated transformation parameter was $\theta = 1.15$, and the null hypothesis that $\theta = 1$ (indicating that no transformation was required) could not be rejected ($p = 0.242$), supporting the adequacy of a linear specification. Regarding heteroskedasticity, we conducted the Breusch–Pagan/Cook–Weisberg test, which did not provide sufficient evidence to reject the null hypothesis of constant variance ($p = 0.3745$). Nonetheless, to ensure robustness, all

Table 6
Conditional logit model results.

	Price	Standard error	Organic	Standard error	ASC	Standard error
Sample	−0.40***	0.02	2.27***	0.11	4.22***	0.20
Memory	−0.39***	0.04	2.03***	0.21	4.50***	0.40
Picture	−0.36***	0.04	2.07***	0.21	3.64***	0.39
VR	−0.45***	0.04	2.47***	0.24	4.92***	0.42
Forest	−0.42***	0.04	2.61***	0.25	3.96***	0.43
Δ P-NF	0.03	0.05	0.04	0.30	−0.86	0.56
Δ VR-NF	−0.06	0.06	0.45	0.32	0.42	0.58
Δ F-NF	−0.04	0.06	0.58*	0.33	−0.54	0.58
Δ VR-P	−0.09	0.06	0.40	0.32	1.29**	0.57
Δ F-P	−0.07	0.06	0.54*	0.33	0.33	0.58
Δ F-VR	0.02	0.06	0.14	0.35	−0.96	0.60

Note. ***p < 0.01; **p < 0.05; *p < 0.1.

regressions were estimated using heteroskedasticity-robust standard errors. The results are presented in Table 8.

The WTP for the presence of organic certification in honey primarily depends on consumers' relationship with the product presented in the DCE. Specifically, product involvement had a positive impact. Additionally, the frequency of organic product consumption also significantly influenced WTP. Among the psychographic variables, only a higher environmental self-identity and greater awareness of consequences are found to affect WTP. Finally, the sense of presence related to the location also influences the dependent variable, indicating that the more consumers feel connected to the forest, the higher their WTP for organic certification.

5. Discussions

Drawing on the connection between nature exposure and sustainable behaviours (Jansen et al., 2024; Sun and Wu, 2023; Redondo et al., 2022), we set out to examine whether different modes of interaction with a natural environment could produce varying effects on sustainability-related attitudes and willingness to pay for organic products. To our knowledge, this is the first study to directly compare real-life environments, virtual reality, static images, and a brief memory-based recall of a forest experience in this context.

One particularly interesting finding relates to the green scale, which measures dietary behaviours linked to sustainability (Haws et al., 2014). Since this variable was controlled for during the initial screening—ensuring the four groups started at the same baseline—the post-exposure increase observed in the Forest group is particularly meaningful. Specifically, participants who completed the questionnaire in the forest scored notably higher on the green scale compared to participants in the "Picture" and "Memory" groups.

We also observed a significant difference in participants' awareness of the future consequences of their actions. Once again, the "Forest" group showed higher levels of awareness than the "Memory" group. These results support the idea that deeper interaction with a forest environment strengthens people's connection to sustainability. This effect is likely attributable to the intensity of the interaction, which we measured using participants' reported sense of presence and location. The "Forest" group clearly stood apart from the other groups in this respect.

Interestingly, the Picture group exhibited a slight yet consistent decrease across most psychographic measures related to attitudes toward the natural environment, with the exception of awareness of consequences. Although these within-group declines were not the main focus of the study, they may reflect a transient self-reflective or comparative process rather than a negative treatment effect. Participants exposed to static images of pristine natural settings might have engaged in upward comparisons with the ecological ideal depicted in the photographs, momentarily perceiving their own behaviours as less environmentally aligned, since media-based upward comparisons are known to produce short-term negative self-evaluations (Vogel et al., 2014). According to the literature, such responses are often temporary and context-dependent, highlighting the subtle and sometimes countervailing ways in which different forms of nature exposure can influence psychological processing and self-perception.

Although our study did not directly measure emotional or cognitive processing, the data offer insight into potential mechanisms. In particular, the sense of spatial presence—especially location—was significantly higher in the Forest group and was positively associated with willingness to pay in the regression analysis. This suggests that immersion in a real natural setting may increase attention to environmentally relevant attributes, thereby reinforcing existing orientations such as environmental self-identity and awareness of consequences. The observed increase in the green scale lends further support this interpretation, indicating that stronger situational engagement can subtly influence individual values and, in turn, behavioural intentions. The absence of significant differences for other variables is also informative, implying that only certain components of environmental attitudes are responsive to experiential exposure.

Moreover, the heterogeneity observed within the Forest group suggests that individual differences may modulate the impact of natural exposure. Beyond the psychographic traits already controlled for in our design (environmental self-identity, nature relatedness, green values, and awareness of consequences), other personal dispositions may help explain the variability in responses. For instance, environmental sensitivity and empathy toward nature have been shown to intensify affective and physiological reactions to natural settings (Costa-López et al., 2024; Setti et al., 2022). Likewise, dispositional mindfulness and reflective cognitive style can influence the depth of experiential engagement, as individuals who are more attentive or contemplative tend to process environmental stimuli more thoroughly (Nisbet et al., 2019; Schutte and Malouff, 2018). In addition, momentary psychological states such as stress, mood, or restorative need at the time of exposure may also shape the strength of the response, introducing situational variability even within psychographically homogeneous groups (Browning et al., 2023; Bratman et al., 2015). Identifying these moderators could therefore help clarify why exposure to the same natural environment elicits distinct attitudinal and behavioural outcomes across individuals.

These results also provide mechanistic support for Connectedness to Nature Theory (CNT), suggesting that sensory immersion—particularly through spatial presence—may be a key pathway linking nature exposure to pro-environmental behaviour. This reinforces the idea that nature functions as a psychologically active stimulus, engaging affective and cognitive processes relevant to sustainability.

Another striking result was the absence of significant differences between the "Memory", "Picture", and "VR" groups in their reported sense of presence or location. Despite advances in virtual technology, participants did not perceive VR as comparable to an authentic natural setting. This finding echoes previous studies in other fields (Pastel et al., 2021; Murray, 2020; Wang, 2020). Instead, participants appeared to categorise VR experiences as more akin to experiences involving pictures or memory-based recall. Some of the feedback we collected at the end of the experiment supports this. Specifically, many participants in the "Forest" group expressed enthusiastic appreciation for the opportunity to engage directly with the natural environment. For example, one participant remarked, "*Thank you for the opportunity to take a short but very conscious break from everyday stress in the middle of everyday life*", and another described it as "*a very relaxed experience*".

While feedback from the other groups was less frequent, it nonetheless offered some valuable insights. A participant in the "Memory" group shared: *"When asked to imagine myself in the forest, I briefly closed my eyes and remembered my last long walk in the woods; this allowed me to relax a lot, and I felt like going for another walk. Thanks:)"*. By contrast, someone in the "VR" group remarked: *"A virtual image can never replace the real one!"*. These examples highlight the diversity of perspectives

Table 8
Linear regression results.

Variable	Coefficient	Standard error
Frequency of organic consumption	0.68***	0.23
Environmental self-identity	1.28**	0.56
Nature relatedness	−0.29	0.28
Awareness of consequences	0.90***	0.30
Green scale	−0.57	0.64
Consideration of future consequences	0.06	0.32
Involvement in sustainable eating	−0.18	0.46
Personal norm	−0.03	0.60
Ascription of responsibility	−0.50	0.34
Product involvement	0.59***	0.18
Spatial presence (location)	0.62**	0.29
Spatial presence (action)	−0.62	0.33
Constant	−5.07**	2.52

Note. ***$p < 0.01$; **$p < 0.05$.

among participants who did not experience the forest in person and could help explain the lack of significant difference between the "Memory" and "VR" groups, while also underscoring the distinctiveness of real-world nature exposure.

Although the three non-forest groups reported similar levels of presence and location, the "VR" group nonetheless warrants further consideration. Participants in the "Forest" group exhibited significantly stronger willingness to pay for sustainable products compared to those in the "Memory" and "Picture" groups. However, the "VR" group did not differ significantly from either the "Forest" or the "Memory" groups. This pattern suggests that virtual reality occupies an intermediate position between less immersive exposures and real-world environments. Although these differences were not statistically significant, the positioning of the VR group implies a potential transitional effect that deserves further investigation. Virtual reality may hold promise as a tool to enhance connection to nature and, ultimately, to promote more sustainable consumption behaviours. While it may not yet fully replicate the experience of being in a real forest, the DCE results indicate that it can contribute to shifts in attitudes, making it a potentially valuable instrument for fostering sustainability.

Our findings not only demonstrate the novelty of the effects stemming from different forms of interaction with natural environments but also reaffirm, through the DCE, the positive influence of organic certification on a product's utility, as underscored in the literature (e.g., reviews by Roy et al., 2023; Eyinade et al., 2021). Although the intensity of effect varied across exposure types, the presence of organic certification consistently enhanced perceived utility. This effect was particularly evident in the mixed logit model, which improved the explanatory power of the overall model. Specifically, it revealed that the beta coefficient for organic certification, though heterogeneous across the sample, was both positive and statistically significant.

Regression analysis examining the influence of variables on WTP corroborates many established findings in the literature. For example, the association between frequent consumption of organic products and higher WTP is well-documented (Maesano et al., 2021). Similarly, the positive influence of awareness of consequences and environmental self-identity on WTP aligns with previous studies (Koshta et al., 2022; Talwar et al., 2021; Hoyos et al., 2015). Furthermore, a higher WTP for organic honey among those with strong product involvement is unsurprising (Hsu et al., 2023). Although not designed as a formal mediation model, this regression framework allows for the examination of interaction-free associations between individual psychological traits and behavioural preferences. The significance of environmental self-identity and spatial presence suggests that these variables may help explain how nature exposure translates into greater WTP for sustainable products.

A novel contribution of our study lies in its focus on the role of the forest. While the relationship between natural settings and WTP is well-established (Jansen et al., 2024; Sun and Wu, 2023; Redondo et al., 2022), our findings highlight that not all forms of nature exposure yield equivalent effects. In particular, real immersion may retain a unique advantage in terms of sensory integration and behavioural influence.

5.1. Theoretical contributions

This study contributes to theory in several ways. First, it extends Connectedness to Nature Theory (CNT) by demonstrating that even brief, real-life exposure to nature—such as a 5-min forest immersion—can lead to measurable shifts in pro-environmental values and behaviour. While previous research has focused primarily on long-term or habitual contact with nature, our results suggest that short-term experiential interventions can also activate affective and cognitive mechanisms relevant to sustainability.

Second, by comparing four different modes of exposure (memory-based recall, static images, VR, and real forest), we offer a more granular understanding of how varying levels of sensory immersion influence psychological and behavioural outcomes. This contributes to refining models of environmental psychology by highlighting the graded effects of immersion on sustainable decision-making.

Moreover, by linking attitudinal shifts to actual behavioural choices through the DCE framework, this study adds empirical weight to the relationship between psychological connection to nature and concrete consumer decisions.

Lastly, the findings support emerging perspectives that conceptualise nature not merely as a setting, but as a psychological stimulus capable of reshaping consumer values and ethical orientations—suggesting new directions for theory on environmental cueing and behavioural priming.

5.2. Practical implications

Beyond theoretical contributions, the study offers several practical insights. The evidence that even brief immersion in natural environments can positively influence both values and behaviour suggests opportunities for real-world applications across education, marketing, and public health. While real forest exposure showed the most consistent effects, our results also indicate that virtual nature, although less impactful, may still serve as a promising tool where direct contact with nature is unfeasible.

These findings suggest that institutions and organisations could incorporate nature-based cues, whether physical or digital, into everyday environments to support more sustainable decision-making. For instance, brief exposure to natural scenes could be offered in school or university settings before meals to foster mindful food choices, while nature imagery and immersive videos could be integrated into cafeterias, supermarkets, or food delivery platforms. In urban contexts where access to real nature is limited, such interventions may act as subtle yet effective nudges toward sustainability. More broadly, the creation of actual green spaces in cities could also have a wider beneficial impact, supporting both well-being and environmentally responsible behaviours.

Moreover, the observed connection between a moment of personal relaxation and a heightened willingness to act in favour of the common good points to a potentially valuable synergy between individual well-being and environmental benefit. Public strategies that foreground nature exposure—whether through infrastructure, events, or behavioural prompts—may simultaneously promote healthier individuals and more responsible consumption behaviours.

5.3. Limitations

While our study provides valuable insights into the role of contact with natural environments in shaping sustainable consumer behaviour, several limitations should be acknowledged.

Sample composition. First, the sample consisted primarily of university students, which limits the generalisability of the findings to broader populations. Although students represent an important and often environmentally conscious consumer group, future studies should incorporate more diverse demographic segments to assess the robustness of the effects across age, educational attainment, and socioeconomic background.

Product and stimulus scope. Second, the discrete choice experiment focused exclusively on organic honey. This was not intended to provide an exhaustive account of sustainable consumption, but rather to serve as a concrete and recognisable proxy for sustainability-related choices. Honey was chosen because of its association with naturalness and its suitability for organic production. While this approach enabled a focus on the psychological effects of nature exposure, future research should investigate a broader range of products and attributes to explore whether the observed effects hold across other domains.

Exposure duration. Third, the duration of exposure across all treatment conditions was very short. While sufficient to detect short-term changes in attitudes and preferences, this limited timespan may not allow for deeper or longer-lasting psychological shifts. Future research

should explore whether longer or repeated exposures lead to more enduring effects on sustainable behaviour.

Stimuli design. Fourth, the VR stimulus was not developed specifically for this study but was selected from publicly available high-quality content. This decision ensured ecological validity and facilitated replicability, as other researchers can easily access and review the exact material used. However, because the content was not tailored to the specific narrative or behavioural goals of the study, its potential for emotional resonance or message alignment may have been limited. Similarly, the static picture and memory-based recall conditions offered only a low level of sensory engagement, and future work could explore more immersive or interactive alternatives for these comparison groups.

Manipulation checks. Lastly, the memory condition did not include manipulation checks, as participants were simply asked to recall their last visit to a forest. This limits our ability to assess the actual depth of symbolic engagement in that group. However, it is important to note that this group was not designed as a full treatment condition but rather served as a *baseline reference point* representing minimal sensory and emotional immersion. Its primary function was to enable comparison with the effects of more immersive exposures (pictures, VR, forest). Nonetheless, future studies should consider incorporating manipulation checks—such as follow-up questions or attention probes—to better assess participant engagement, even in low-immersion conditions.

These limitations open important avenues for future research. Specifically, the use of more refined and interactive VR content, richer multimodal stimuli, extended exposure durations, and more heterogeneous samples may allow for a deeper exploration of the mechanisms through which nature exposure influences sustainable decision-making.

6. Conclusions

This study investigated how different degrees and formats of forest immersion—ranging from memory-based recall to direct contact with nature—can influence attitudes toward sustainability and food choice behaviour. By integrating psychographic measures and a discrete choice experiment, we found that real forest exposure had the strongest impact on green values, awareness of consequences, and willingness to pay for organic honey. Virtual reality showed intermediate effects, while picture and memory-based recall conditions were less effective in shifting either attitudes or choices.

These findings contribute to both theory and application. Theoretically, they confirm that even short-term interactions with natural environments can activate affective and cognitive mechanisms that promote sustainability, particularly when the exposure is sensorially rich and immersive. From a practical perspective, the results suggest that nature-based interventions—whether physical or digital—could be strategically integrated into everyday contexts such as schools, cafeterias, and retail environments to support more conscious consumption.

Furthermore, the observed link between personal relaxation and prosocial orientation points to a synergy between environmental and human health that could be leveraged in public strategies. Embedding opportunities for nature exposure into urban infrastructure, education, and public health campaigns could foster not only individual well-being but also broader sustainability outcomes.

Future research could build on these results by testing different natural settings, integrating more interactive or multisensory VR experiences, and exploring the durability of the observed effects over time. As the imperative for sustainability intensifies, understanding how environmental cues influence behaviour will be essential for designing more effective interventions and policies.

CRediT authorship contribution statement

Tommaso Fantechi: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Antje Risius:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Caterina Contini:** Writing – review & editing, Supervision. **Caroline Reinhardt:** Methodology, Data curation. **Clara Mehlhose:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors hereby declare that they have no financial or personal relationships with any individuals or organisations that could be perceived as having the potential to influence or bias the content of this work. There are no competing interests to disclose.

Furthermore, the authors confirm that there are no declarations related to employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications or registrations, or any other forms of funding.

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Data availability

Data will be made available on request.

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