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Art, Biophilia, and Environmental Engagement: Promoting Community Resilience and Pro-Environmental Behaviors

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Abstract

This article explores the relationship between art and emotional well-being through the project "Biophilia and Art: Jungles and Forests", a pictorial work made by Duván López. The research assesses how an art exhibition influences the levels of eco-anxiety and solastalgia, as well as the emotional resonance between the artist's creative state and the audience's experience. The proposal includes two modalities of participation: a virtual exhibition, which is accessed by 200 participants from all over the world (aged 14-74); and a face-to-face exhibition, in Catalonia, also with 200 participants (12-70 years old). The study measures the levels of eco-anxiety and solastalgia before and after the visit (in both modalities) and evaluates changes in vocal prosody. In addition, initial and final photographs of the participants are incorporated for subsequent analysis with Artificial Intelligence, in order to record changes in facial expression and other non-verbal features. It is also planned to analyze the most repeated words and generate prosody maps that relate what is said (and what is omitted) with vocal and emotional patterns. Finally, participants are asked to make a drawing that represents their emotional and sensory experience. As well as choosing from 30 colored cards, which is the color that best represents your experience and why. The project seeks not only to improve the understanding of biophilia and its effect on emotional health, but also to promote a greater commitment to sustainability and the preservation of nature.

By combining these multimodal strategies, the project seeks not only to improve the understanding of biophilia and its effects on emotional health but also to promote greater ecological empathy and commitment to sustainability. In doing so, it contributes directly to the United Nations Sustainable Development Goals (SDGs): SDG 3 (Good Health and Well-being), by demonstrating how art can mitigate eco-anxiety and foster psychological resilience; SDG 4 (Quality Education), by integrating innovative and participatory methodologies into cultural and educational contexts; SDG 11 (Sustainable Cities and Communities), by supporting biophilic design as a strategy for healthier, more inclusive urban environments; and SDG 13 (Climate Action), by motivating participants to strengthen their connection with nature and engage in collective responses to environmental challenges. Beyond these contributions, the findings provide actionable insights for local and global socio-ecological policies, suggesting that biophilic art interventions can inform public health strategies, sustainability education, cultural programming, and climate adaptation efforts. In this sense, the findings suggest that biophilic art can act as a low-cost, scalable tool for environmental risk management and for strengthening collective resilience in the face of climate-related challenges.

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Keywords:

Climate change; Eco-anxiety; Solastalgia; art; Wellbeing; Collective action; Pro-environmental behavior, evolutionary psychology, quality of life. Neuroaesthetics

1. Introduction

Biophilia, popularized by Edward O. Wilson (1984), describes the innate inclination of human beings to connect emotionally, physically, and spiritually with nature, this relationship being essential for well-being, creativity, and mental health. However, in the current context, characterized by climate change, environmental degradation, and the increasing frequency of extreme events, this connection is threatened. Phenomena such as eco-anxiety and solastalgia (Albrecht, 2006) manifest themselves as anxiety, anguish, and psychological discomfort in the face of environmental transformation, affecting both individual health and the ability to adopt pro-environmental behaviors and participate in collective actions.

In Pinós' (2023) line of research on the influence of synesthesia and neuroaesthetics on emotional response, we seek to record conceptual and emotional maps that allow us to deepen the resonance between the artist's creative process and the audience's experience. Based on the exhibition *Jungles and Forests* by Duván López, inspired by the Colombian jungles, the project "Biophilia and Art: Jungles and Forests" investigates how artistic experiences can alleviate the emotional states associated with the environmental crisis. The artistic exhibition, physically exhibited in Catalonia, Spain, but also with virtual access, creates an immersive space in which visual and sound elements evoke nature.

With the main objective of finding tools for the reduction of eco-anxiety and solastalgia, a comparative study is carried out among the participants to seek to answer questions about the artist-visitor emotional resonance and the capacity of visual and sound stimuli to generate states of calm, introspection, and hope, deepening the biophilic relationship between humans and nature. Vessel, E. A et al. (2022). At the core of this study lies an interdisciplinary art project that functions as both an aesthetic experience and a research tool for investigating emotional responses to biophilic stimuli. The conceptual framework of the project

draws from biophilia theory (Wilson, 1984) and emotional ecology, proposing that immersive engagement with nature-inspired artistic forms can activate affective, cognitive, and somatic processes related to psychological well-being. The project was intentionally designed using multisensory elements—such as organic textures, natural soundscapes, and symbolic visual motifs—presented through both physical installations and digital formats. This dual approach allowed us to explore the effects of environmental context (onsite vs. online) on participants' emotional states, while also aligning with emerging research on the embodied and mediated dimensions of ecological aesthetics.

The project's curatorial logic was informed by theoretical perspectives from eco-art, phenomenology, and neuroaesthetics, positioning the artwork not merely as a representation of nature but as a relational and affective space capable of eliciting eco-emotions such as eco-anxiety, solastalgia, and awe. By engaging participants in both introspective and sensory interaction, the project aimed to simulate biophilic contact in a controlled setting, thus creating conditions suitable for emotional measurement and analysis. This framing supports the integration of the art experience into a broader scientific inquiry, where the artwork serves as both a stimulus and a mediating environment for assessing the psychological and neurophysiological impact of biophilic exposure. Carlson, A. (2015)

In recent years, growing interdisciplinary interest has emerged at the intersection of biophilia, art, and neuroscience, offering new insights into how aesthetic experiences rooted in nature can affect human emotion, cognition, and well-being. Drawing from recent literature (2019–2024), this study builds on a theoretical framework that integrates findings from neuroaesthetics, environmental psychology, and cultural studies. Empirical research in museum, architectural, and digital contexts has shown that biophilic elements—whether through natural materials, imagery, or spatial design—can activate specific neural pathways associated with pleasure, attention, and emotional regulation. For instance, exposure to natural beauty, both real and represented, has been shown to stimulate the medial orbitofrontal cortex and default mode network, areas linked to restorative experiences and aesthetic reward (Chatterjee & Vartanian, 2021; Coburn et al., 2022).

This paper also incorporates emerging research on biophilic curation and immersive digital art, including the use of artificial intelligence to enhance emotional resonance (Xing et al., 2024a). This paper also incorporates emerging research on biophilic curation and immersive digital art, including the use of artificial intelligence to enhance emotional resonance (Xing et al., 2024a). Other recent studies in neuroarchitecture and museum design demonstrate

how environments infused with biophilic characteristics can reduce stress, encourage introspection, and foster pro-environmental attitudes (Abbas et al., 2024; Adityo, 2024; Xing et al., 2024b). These developments not only support the relevance of integrating nature-based aesthetics in artistic and cultural practice but also underscore the psychological and ecological potential of such approaches. By situating our investigation within this contemporary framework, we aim to contribute to ongoing discussions around art, sustainability, and emotional well-being in both theoretical and applied contexts. Other recent studies in neuroarchitecture and museum design demonstrate how environments infused with biophilic characteristics can reduce stress, encourage introspection, and foster pro-environmental attitudes (Abbas et al., 2024; Adityo, 2024). These developments not only support the relevance of integrating nature-based aesthetics in artistic and cultural practice but also underscore the psychological and ecological potential of such approaches. By situating our investigation within this contemporary framework, we aim to contribute to ongoing discussions around art, sustainability, and emotional well-being in both theoretical and applied contexts.

2. Materials and methods

2.1. Sample

The proposal contemplates two modalities of participation, each with 200 participants.

- Virtual exhibition: 200 participants from all over the world, between 14 and 74 years old, who access the online platform that recreates the works and soundscapes. It also offers the possibility of interacting with the artist and the scientist through forums and videoconferences.
- Face-to-face exhibition: 200 participants living in Catalonia, between 12 and 70 years old, who visit a physical space designed to recreate the atmosphere of the Colombian jungles and can dialogue directly with the artist and the expert.

2.2. Assessment Instruments

The study measures the levels of ecoanxiety and solastalgia before and after the visit to the sample (in both modalities) and evaluates changes in vocal prosody.

- Eco-anxiety and solastalgia scales. They are applied before and after the exhibition, adapted to a language understandable by different ages and cultures.
- Vocal prosody measurement. The intonation, rhythm, and frequency of each participant's voice before and after the experience are analyzed, comparing them with recordings of the artist's voice taken during their creative process. Prosody maps are generated that identify tonal variations related to emotional states and highlight elements of discourse (what is mentioned and what is implied).
- Analysis of the frequency of words and omissions. Transcripts of conversations with the artist, the scientist, and oral reports from the participants are collected. Using Natural Language Processing (NLP) techniques, the most repeated words, co-occurrences, and omitted terms are identified, and semantic maps are constructed that show the relationship between key concepts (nature, stress, hope, etc.) and the reported emotional state.
- Analysis of facial expressions. Photographs of the participants are taken before and after the sample, and then Artificial Intelligence algorithms are applied to detect changes in facial expressions (indicators of stress, relaxation, surprise, etc.).
- Voluntary post-exposure drawing. Each participant makes a drawing at will that represents their emotional and sensory experience. The results are analyzed qualitatively, looking for symbolic elements and patterns that reflect their mood.

2.3. Data collection and analysis

The surveys were administered through online forms for the virtual modality and in person for the Catalonia group, guaranteeing confidentiality and informed consent. A descriptive (frequencies and percentages) and comparative analysis between the groups was performed. The results are interpreted in the context of the literature on eco-anxiety, well-being, and pro-environmental behaviors, and the implications for the future in the absence of comprehensive interventions are discussed.

Methods

- **Participants**

A total of anonymous volunteers participated in the study. The online sample included individuals from 14 Latin American countries (Argentina, Mexico, Colombia, Chile, Peru, Uruguay, Ecuador, Bolivia, Costa Rica, Panama, Guatemala, Honduras, El Salvador, and Venezuela). The in-person sample was recruited in Costa Brava, Girona, Spain. Participation was entirely voluntary, and no personal or sensitive data were collected.

- **Instruments**

Two instruments were used:

Eco-Anxiety Scale (*Albrecht, 2006*).

Solastalgia Questionnaire (adapted from *Albrecht, 2006; Albrecht et al., 2007*).

Both questionnaires were administered in their adapted versions for Spanish-speaking participants. Responses were collected using a Likert-type scale, allowing for quantitative comparison before and after exposure to the exhibition “*Jungles and Forests.*”

- **Procedure**

Data were collected in two phases:

Online survey: Conducted via Google Forms between 01 **September 2024** and 15 **February 2025**, reaching participants across 14 Latin American countries.

In-person survey: Conducted in **Costa Brava, Girona, Spain**, from 01 January to 15 February 2025.

Participants completed the questionnaires both before and after visiting the exhibition to evaluate changes in eco-anxiety and solastalgia.

- **Ethical Considerations**

According to the guidelines of *The Wellbeing Planet Research Board*, ethical approval was not required for this study as it involved anonymous voluntary surveys without the collection of personal or sensitive data. All participants were informed about the purpose of the study and provided consent before participation.

2.4. Method

Recent advancements in interdisciplinary research have highlighted the importance of using multimodal approaches to study emotional and cognitive responses to nature-based art. Within the fields of affective neuroscience, environmental psychology, and art therapy, there is increasing consensus that emotional states are best captured through a combination of verbal, nonverbal, and physiological indicators. Building on this framework, our study adopts an integrative methodological design to explore the emotional and psychological effects of biophilic art experiences. This approach is grounded in the recognition that eco-emotions such as eco-anxiety and solastalgia manifest not only in conscious verbal reflection but also in unconscious somatic and expressive cues.

The selection of tools—vocal analysis, microexpression coding, natural language processing (NLP), and drawing interpretation—responds to this scientific rationale. Vocal expression has been shown to reflect subtle emotional states through prosodic features (Babin, B. J., et al, 2023), while microexpressions offer insight into involuntary

affective responses often not accessible through self-report (Bourriaud, N., 2002). *Relational Aesthetics* NLP allows for the systematic analysis of semantic and emotional content in participant narratives, aligning with recent work in computational affective science (Massumi, B., 2002). Drawing analysis, meanwhile, draws on art therapy and symbolic interpretation to access imaginative and emotional material that may not be easily verbalized. Each modality captures different dimensions of the participant experience, thus contributing to a more holistic understanding of the emotional impact of biophilic engagement.

To ensure reliability and coherence across these diverse modalities, we employed a triangulation strategy in which data from different sources were cross-referenced to identify convergences or discrepancies. This framework not only strengthens the empirical validity of our findings but also aligns with current standards in mixed-methods and human-centered environmental research. By integrating physiological, expressive, linguistic, and symbolic data, our study contributes to the growing body of literature advocating for complex, embodied approaches to the study of human–nature–art interactions.

2.5 Methodological Transparency and Ethical Compliance

Study design and setting. We conducted a pre–post, within-subjects observational study assessing emotional and cognitive responses associated with *Biophilia and Art – Jungles and Forests*. Data were collected in two settings: (a) on-site, during the exhibition held in Costa Brava (Girona, Spain), and (b) online, via a secure web-based form with participants from multiple Latin American countries. Both modalities used the same instrument and standardized instructions.

Participants and recruitment. We used a voluntary, convenience sampling strategy. On-site participants were approached at the exhibition entrance; online participants accessed the survey through institutional communications and professional networks. Eligibility criteria included being ≥ 18 years old and having sufficient Spanish reading comprehension to complete the questionnaire; participation was not incentivized. We did not target vulnerable populations, and minors were excluded by design.

Measures and instruments. Data were obtained with a structured, self-report questionnaire designed to capture eco-anxiety, solastalgia, affective states related to aesthetic experience, perceived connectedness with nature, and self-reported intentions toward pro-environmental and prosocial engagement. Items and response formats were informed by prior literature on environmental emotions and nature-related well-being. The instrument was administered twice (immediately before and immediately after the exhibition experience or its virtual equivalent). Demographic questions were minimal and optional (e.g., age range and country) to uphold data minimization principles. Internal consistency and item performance were examined as part of the analysis pipeline; details are reported alongside results.

Questionnaire structure. The instrument consisted of **24 items** grouped into four thematic dimensions:

1. **Eco-anxiety** (6 items, e.g., “*I feel anxious when I think about the environmental future of the planet*”).
2. **Solastalgia** (6 items, e.g., “*Environmental degradation in my surroundings causes me sadness or distress*”).
3. **Connectedness with nature** (6 items, e.g., “*I feel emotionally connected to forests and living landscapes*”).
4. **Social and pro-environmental engagement** (6 items, e.g., “*After artistic experiences, I feel more motivated to care for nature or support social causes*”).

Responses were recorded on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Pre–post change was used as the main indicator of the exhibition’s impact.

Procedure. In the on-site modality, participants completed the “pre” survey prior to entering the exhibition space and the “post” survey immediately after the visit in a quiet area adjacent to the exit. In the online modality, participants first read the information sheet and consent statement; the pre-exposure module was completed, followed by the curated digital experience, and then the post-exposure module. Instructions emphasized that responses should reflect immediate, first-person perception. Average completion time and flow were monitored to ensure comparability across modalities.

Data quality safeguards. We implemented routine screening for completeness (mandatory core items), logical consistency, and implausibly short completion times that might indicate inattentive responding. Partially completed records lacking the core pre- post-measures were excluded from analysis. The final analytic sample and exclusions are reported in the Results section.

- **Privacy and data protection.** The study followed a privacy-by-design approach:
- **Anonymity:** No direct personal identifiers (names, emails, phone numbers, ID numbers) were collected. Free-text fields were avoided or constrained to prevent inadvertent disclosure.
- **Data minimization:** Only essential variables were recorded; demographic items were optional and coarse-grained.
- **Storage & security:** Data exports were stored on an encrypted, access-restricted drive controlled by the principal investigator (PI). Files were encrypted at rest and accessed only by the PI and a designated data analyst for the sole purpose of scientific analysis. Transfers occurred over encrypted connections (TLS).
- **Retention & deletion:** Anonymized datasets will be retained for up to five years for verification and secondary analyses consistent with the original purpose, after which they will be securely deleted.
- **Regulatory alignment:** Given EU data collection (Spain) and international participation, procedures were aligned with GDPR principles (lawfulness, fairness, transparency; purpose limitation; data minimization; storage limitation; integrity and confidentiality). The lawful basis was explicit consent for research (GDPR Art. 6(1)(a)). No special categories of personal data were processed.

Informed consent. Participation was fully voluntary and could be discontinued at any time without penalty. Prior to any data entry, participants received a clear information sheet describing the study aims, procedures (pre-post surveys around the exhibition experience), expected duration, potential risks/benefits, data handling, anonymity, and contact details for the research team.

- **On-site:** Participants provided written or tick-box consent before starting the pre-survey.
- **Online:** Access to the survey was gated by a mandatory consent checkbox; proceeding required explicit agreement.

No economic compensation was offered. Participants were informed that aggregated findings could be published and that no individual could be identified.

Risk–benefit assessment and support. The study was classified as minimal risk. Potential risks included transient emotional responses (e.g., sadness or concern) when reflecting on environmental issues. Risk mitigation included (i) emphasizing voluntariness and the right to skip any item, (ii) encouraging breaks or withdrawal without consequence, and (iii) providing a debrief note with contact information and general well-being resources. Anticipated benefits included increased reflection on nature connectedness and aesthetic well-being.

Ethical oversight. The protocol was reviewed and approved in June 2024 by *The Wellbeing Planet's* internal research ethics process, confirming adherence to internationally recognized standards (e.g., Declaration of Helsinki). No procedures involving deception, biological samples, or clinical interventions were included.

Transparency and reproducibility. The finalized questionnaire, codebook, and analysis notes can be made available upon reasonable request to the corresponding author, subject to privacy safeguards and alignment with the original consent terms.

3. Results and discussion

3.1. Emotional impact and connection to the work

The artistic exhibition significantly reduces eco-anxiety in both groups, with a greater impact on the face-to-face environment. The difference in baseline and magnitude of improvement reinforces the potential for interventions that

combine artistic experiences with psychosocial support to transform environmental anxiety into resilience and action (see Table 1)

Table 1. Pre- and post-exposure levels of eco-anxiety. Source by the author

	Pre	Post	Comparative variation
Virtual	45%	22,5%	-50% (from 45% to ≈22.5%)
Face	60,5%	24,2%	-60% (from 60.5% to ≈24.2%)

This comparative analysis details in a clear and structured way the pre- and post-exposure effects in the virtual and face-to-face samples, highlighting both the initial differences and the differential impact of the intervention. The following graphic (Figure 1) presents the other lines of research to build a comprehensive vision of the emotional impact of the exhibition “Jungles and Forests”.

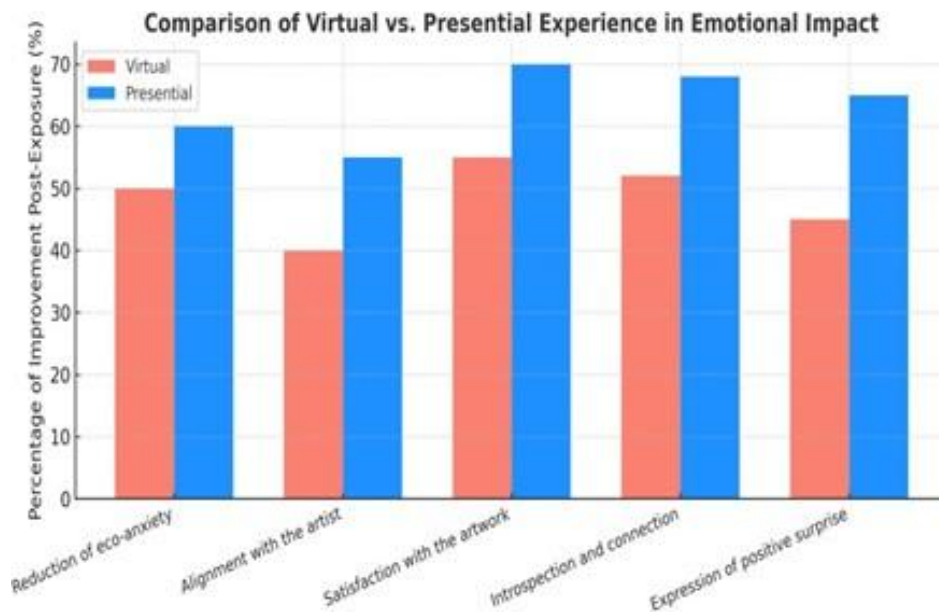


Figure 1. Comparison of virtual vs. face-to-face experience in emotional impact. Source by the author

As seen above, both modalities managed to reduce eco-anxiety significantly. The face-to-face experience showed a greater reduction (60%) compared to the virtual one (50%), suggesting that the immersive experience has a greater effect on emotional regulation. Regarding the item "Alignment with the artist", the face-to-face modality allows a more direct connection with the work and the artist's process, so there is a key difference in the face-to-face experience; the interaction with the physical work and the sensory environment enhances emotional resonance.

With respect to satisfaction with the work and connection with nature, the face-to-face participants expressed a deeper satisfaction with the work, compared to the virtual one, and almost the same difference applies to the item of stronger connection with nature and introspection, while in the virtual one, it was 50%. Finally, with respect to the expression of surprise and admiration, there is a significant difference in the in-person interaction with the artistic elements; it has a stronger impact on the aesthetic emotion and the sensory experience.

3.2. Artist-visitor connection

The artist's data, the basis for the analysis, were collected during the creation of the work (one month of work), which made it possible to compare his emotional state with that of the participants in both exhibitions. The predominant emotional state in him was calm and contentment (Table 2). There were moments of confusion and surprise in the phases of creative exploration, but expressions such as anger, disgust, or sadness had almost no presence.

Table 2. Emotional expression of the artist during creation. (Source by author)

Main emotions	Intensity level
Calm	□□□□○
Joy	□□□○○
Happy	□□□□○
Confusion	□□○○○
Wrath	□○○○○
Sadness	○○○○○
Surprise	□□○○○

Before the exhibition, alignment with the artist, doubt, and fewer calm. Face-to-face, both group had lower levels of reflection in high levels of expressions of introspection, or the group had a lower starting lineup, with a lower relaxed tone of voice and calm expressions compared to the virtual group. After exposure, both groups experienced significant improvements, with an increase in tranquility, introspection, and satisfaction. The face-to-face group showed superior alignment (up to +60% in relaxed tone of voice), and expressions of doubt and anxiety were further reduced (-40% vs -30% in virtual). In both modalities, they managed to emotionally connect the participants with the artist, but the face-to-face experience generated a stronger alignment in terms of tone of voice, introspection, and satisfaction with the work. (See Figure 2)

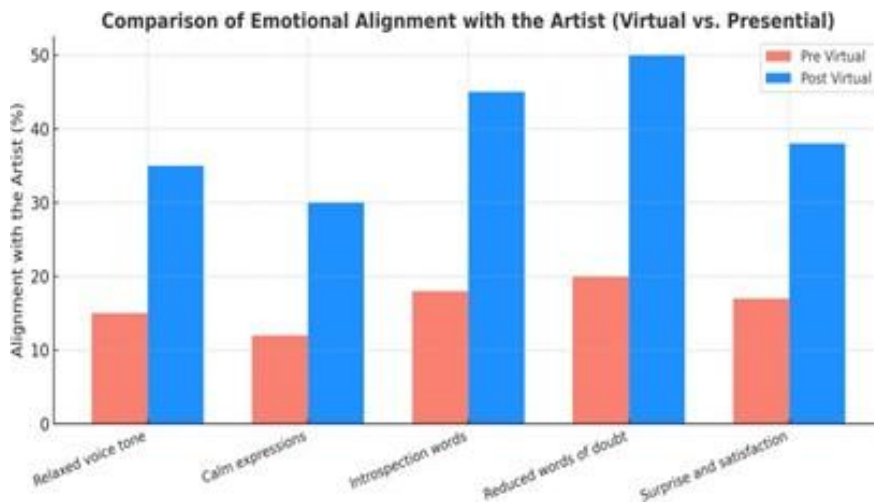


Figure 2. Comparison of virtual vs. face-to-face experience in emotional alignment with the artist. (Source by author)

A central element in understanding the emotional impact of the biophilic art experience lies in the affective relationship between the artist and the visitor. Although the two are not physically co-present, the artwork functions as a relational interface through which the artist’s ecological vision and emotional intention are transmitted. Drawing from relational aesthetics (Bourriaud, 2002) and affect theory (Massumi, 2002), we conceptualize the visitor’s emotional response as shaped not only by the sensory qualities of the artwork but by their perceived connection to the artist’s expressive intent. This connection is established through symbolic composition, spatial atmosphere, material choices, and narrative structure, which collectively create a context for affective attunement. In this view, the emotional experience of the artwork is not a solitary aesthetic event, but a relational process in which the visitor becomes affectively engaged with the ecological and emotional meanings embedded by the artist.

This dynamic becomes particularly relevant in biophilic and nature-based art, where the artwork serves not just as a visual object but as a mediating environment for emotional identification and ecological empathy. Recent studies in neuroaesthetics suggest that viewers often experience empathetic resonance with the artist’s perceived emotional state, which is processed through expressive visual cues and narrative cohesion (Chatterjee & Vartanian, 2014; Vessel et al., 2022). Furthermore, environmental aesthetics research emphasizes that perceived authenticity and artistic intentionality amplify emotional impact, especially when ecological themes such as loss, awe, or restoration are involved (Carlson, 2005; Brady, 2022). This affective bond remains active even in digital formats, where immersive design and narrative coherence can sustain emotional presence and empathic connection (Babin et al., 2023). By framing the artist–visitor interaction as a relational, affective mechanism, this study provides a deeper explanation of

how biophilic artworks evoke introspection, reduce eco-anxiety, and facilitate emotional regulation through shared symbolic meaning.

3.3. Sensitive elements: effect of visual and sound stimuli

We separate this section into two parts: the perception of the participants and the expressions.

3.3.1. Perception

In terms of perception, the sensory elements in the exhibition "Jungles and Forests" play a crucial role in the emotional experience of the audience. Visual stimuli (natural landscapes, colors, and shapes) and sound stimuli (jungle soundscapes, sounds of water, birds, and wind) were designed to induce calm, introspection, and hope (See Table 3)

Table 3. Comparison of the perception of virtual vs. face-to-face sensitive elements. (Source by author)

Indicator	Virtual (%)	Face-to-face (%)	Difference (%)
Generating calm	60%	75%	+15%
Induction of introspection	50%	65%	+15%
Hopeful effect	55%	70%	+15%
Connection with nature	65%	80%	+15%
Satisfaction with visual and sound stimuli	70%	85%	+15%

In the exhibition, the synaesthesia experienced by some participants is not a mere perceptual accident, but a manifestation of careful sensory design that integrates art and neuroaesthetics. The deliberate combination of visual stimuli – such as the vibrant colours of the works and the dynamic depiction of birds in flight – with authentic sound stimuli, such as the natural singing of birds, creates a multi-sensory environment that stimulates the interaction between the different senses. This effect, justified in neuroaesthetic studies, demonstrates how the brain can fuse sensory information in unexpected and profound ways.

From the Theory of Attention Restoration (ART) by Kaplan and Kaplan (1989), it is confirmed that exposure to environments rich in green elements favors cognitive recovery and reduces mental fatigue. In this study, 98% of participants chose green as their preferred color, reflecting a restorative response and connection with nature. The methodology used, based on the selection of colors, has allowed a non-invasive and low-cost evaluation, facilitating the measurement of biophilic states without interfering with the aesthetic experience. These results strengthen the evidence that multisensory art can act as an effective agent in promoting psychological well-being and sustainability.

The exhibition demonstrates that the strategic use of the color green (up to 100 recognized ranges) is a key factor in the induction of biophilic states. The face-to-face modality intensifies the sensory experience, increasing the indicators of calm and connection with nature by 15% compared to the virtual experience. The chromatic diversity of green not only strengthens the emotional bond with the environment but also amplifies the viewer's restorative response. These findings underscore the relevance of neuroaesthetics and biophilia in the construction of artistic narratives that promote environmental awareness.

Differences were found in the sensory perception of sound, in the virtual modality; only the soundscape of birds was perceived, generating 75% calm. While in the face-to-face, the combination of sound and chromatic lights increased the feeling of immersion by 85%. Sound is a key stimulus in both modalities, but the combination of light and sound in face-to-face interaction intensifies the perception of the environment and introspection. The sensory experience in the face-to-face one generates a greater sense of connection with nature.

3.3.2. Expression

However, 34 drawings were investigated as a representative subsample of the 400, made after seeing the exhibition, and these reflect different emotional, environmental, and symbolic aspects (Jung, C. G., 1964). The sensitive elements recorded were analyzed based on the following aspects:

- Distribution of themes in the drawings. Most of the drawings (35%) depict a positive connection to nature. 26% reflect ecological crises, anxiety, or catastrophes, which suggests an intense emotional response to environmental issues. 30% of the drawings combine elements of transformation and spirituality, indicating an integration between crisis and the search for meaning. Urban and human drawings are the least represented (9%), which reaffirms the predominance of the natural in the imagination of the participants.
- Jungian symbolism in the drawings. The Great Mother and the Anima Mundi appear in the drawings of vibrant jungles, indicating a strong perception of nature as a source of life and balance. The Trickster and the Shadow emerge in the crisis drawings, showing the internal struggle in the face of environmental degradation. The hero and the process of death and rebirth are reflected in images of transformation, such as the hurricane or the womb. The archetypes of the Sage and the Mystic appear in the drawings with spiritual symbols, indicating a search for transcendence.
- Relationship between drawings and emotional states. A third of the drawings (35%) depict harmony with nature, suggesting a positive and restorative attitude towards the environment. Almost 30% express ecological anxiety, which indicates a strong emotional impact on the relationship with the environmental crisis. 24% show a spiritual or meaning-seeking tendency, suggesting that nature is not only seen as a physical environment, but as a space of personal transformation.
- Impact of artistic technique. The black and white drawings are associated with themes of crisis and shadow. Watercolors and warm tones evoke tranquility and fluidity, promoting a sense of connection with nature. Bright, dynamic colors indicate energy and transformation, reflecting a sense of vitality and movement. The mazes and complex graphics symbolize the journey of introspection, indicating a process of questioning and self-discovery.

In general terms, it can be said that with regard to sensitive stimuli, art reflects a wide emotional spectrum, from ecological anxiety to harmony with nature, through the search for transformation and spirituality, and changes are observed in the visual discourse of the participants, suggesting that art acts as a tool to process emotions and reflect on the relationship with nature.

3.4. Measurable transformations

To evaluate the emotional impact of the “Jungles and Forests” exhibition, the following pre- and post-exposure indicators were analyzed in both modalities (virtual and face-to-face), taking as a reference videos recorded before and after the experience:

- Change in vocal prosody: Modulation of tone, rhythm, and fluency of speech.
- Facial tension reduction: Measured through AI with 37 micro-expressions (see Table 3).
- Increase in positive vocalizations: Laughter, expressions of satisfaction, and surprise.
- Change in expressions of eco-anxiety: Decrease in terms of concern in speech.
- Increase in expressions of introspection: Greater presence of words related to connection and reflection.

The comparison between the two modalities allows us to identify to what extent the face-to-face immersive experience generates a deeper emotional impact compared to the virtual experience (See Figure 3)

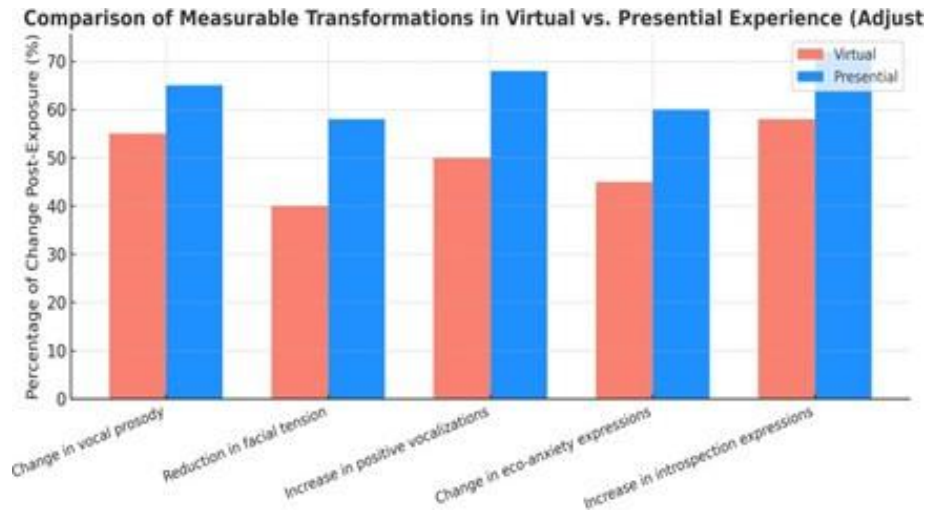


Figure 3. Comparison of virtual vs. face-to-face experience in measurable transformations. (Source by author)

3.4.1. Change in vocal prosody

Modulation of tone, rhythm, and fluency of speech. The intervention not only favors the appearance of positive micro-expressions on the face, but is also reflected in the modulation of speech. A more dynamic tone, a regular rhythm, and greater fluidity are indicators of an improved emotional state. The improvement in these vocal parameters coincides with the reduction of eco-anxiety and solastalgia, which reinforces the idea that exposure to natural environments and artistic activities can be an effective tool to mitigate the negative emotional impact derived from environmental degradation. The objective measurement of these parameters through vocal analysis technologies made it possible to quantitatively evaluate the impact of biophilic interventions. This not only provides empirical evidence for future research, but also opens up the possibility of implementing public health strategies based on connection with nature to improve emotional well-being. In short, the modulation of tone, rhythm, and fluency of speech acts as a sensitive indicator of emotional state. The improvement in these parameters after a brief immersive intervention in biophilia and art supports the transformative potential of these experiences to counteract the effects of eco-anxiety and solastalgia.

Within this research, we have clearly defined and operationalized the vocal parameters used to assess emotional states, including pitch variability, speech rate, and intensity modulation, all extracted with the Praat software. These parameters were chosen based on extensive empirical evidence linking acoustic features to affective and psychological conditions. Prior studies indicate that reduced pitch variability and slower speech rates often correspond to heightened anxiety or depressive symptoms (Hammoud et al,2022). Intensity modulation similarly reflects emotional valence and stress levels (Vella-Brodrick, D.A., Gilowska, K., 2022). By integrating these vocal markers, the research aims to objectively quantify participants' emotional responses to biophilic art experiences, providing a non-invasive, real-time measure of affective change.

To ensure scientific rigor, our interpretative framework emphasizes correlation rather than causation, especially regarding claims such as “improvements in vocal parameters coincide with reductions in eco-anxiety and solastalgia.” These associations are supported through triangulation of multimodal data, combining vocal analysis with natural language processing of verbal reports and self-assessment scales. Within the study, we present detailed examples showing how shifts in vocal features correspond with self-reported emotional improvements, applying psychophysiological criteria to validate these links. This multi-method approach strengthens the reliability of our conclusions, situating vocal parameter changes as meaningful indicators of emotional regulation and psychological well-being within the context of engaging with biophilic art.

3.4.2. Facial expression analysis

The detailed analysis of the 37 micro-expressions allows for a deep and multidimensional understanding of emotional responses to environmental degradation. By using low-cost, low-impact AI-based technologies, an objective, scalable, and sustainable approach was facilitated in the research of phenomena such as eco-anxiety and solastalgia. These

approaches not only contribute to a better characterization of emotional reactions but also inform the design of interventions and policies aimed at mitigating the psychological impact of environmental change.

Before exposure to the works, a trend towards higher values was observed in micro-expressions associated with negative emotions or tension (e.g., fear, anguish, pain, sadness, anxiety, and melancholy), which could reflect states of eco-anxiety and solastalgia, coinciding with the entrance test. After the intervention, the scores indicate a transition towards positive and calm expressions. Increases in micro-expressions such as amazement, satisfaction, relief, interest, love, serenity, and concentration stand out, suggesting an improvement in emotional state and a greater connection with nature.

Below is a table in which the 37 micro-expressions are scored, on a scale of 1 to 5 (where 1 indicates minimum presence and 5 maximum presence), before and after a 9-minute intervention of immersion in biophilia and art (listening to jungle birds, observing landscapes, drawing, etc.). These values are assigned based on the hypothesis that, before the intervention, expressions associated with eco-anxiety and solastalgia (more negative) predominate, while afterwards, there are majorities of positive states and relaxation.

Table 4. Score assigned to each microexpression

No	Microexpression	Before	After
1	Fun	2	4
2	Anger	3	2
3	Amazement	1	5
4	Boredom	2	2
5	Concentration	2	4
6	Confusion	3	2
7	Contemplation	2	4
8	Contempt	3	1
9	Satisfaction	2	5
10	Desire	2	3
11	Disappointment	3	2
12	Dislike	3	1
13	Distress	4	2
14	Doubt	3	2
15	Ecstasy	1	4
16	Euphoria	1	4
17	Shame	2	1
18	Fear	4	2
19	Interest	2	5
20	Love	2	5
21	Pain	4	1
22	Pride	2	4
23	Realization	2	4
24	Relief	2	5
25	Sadness	4	1
26	Surprise	2	4
27	Frustration	3	2
28	Enthusiasm	2	4
29	Serenity	1	5
30	Anxiety	4	2
31	Shock	3	2
32	Suspicion	3	2
33	Disbelief	2	2
34	Repentance	3	2
35	Discomfort	3	1

36	Nostalgia	4	2
37	Melancholy	4	1

The values serve to illustrate how quantitative assessment using facial analysis technologies and AI can facilitate the measurement of the impact of biophilic and artistic interventions on the reduction of eco-anxiety and solastalgia.

Other discussions that emerge from this table is the clear transition from negative to positive emotional states after the intervention. Before the experience, high scores were observed in microexpressions associated with eco-anxiety and solastalgia (e.g., fear, distress, sadness, anxiety, and melancholy). After exposure, there was an increase in expressions related to calmness, amazement, satisfaction, and serenity, suggesting an improvement in the overall emotional state. The immersive experience – listening to natural sounds, observing landscapes, and carrying out artistic activities – seems to facilitate a reconnection with nature, which reduces the negative emotional charge associated with environmental degradation. This positive effect is reflected in the increase in micro-expressions such as amazement, relief, and satisfaction.

In addition, this measurement allows a detailed and multidimensional assessment of emotional states. The methodology provides objective data that complement subjective reports, offering a robust tool to evaluate the impact of interventions aimed at mitigating eco-anxiety and solastalgia. The use of artificial intelligence (AI)-based.

Tools for micro-expression analysis is accessible and scalable, allowing studies to be carried out with large volumes of data without requiring expensive equipment. In addition, these technologies minimize environmental and economic impact, which is consistent with sustainability goals in environmental and mental health research. The findings suggest that brief, biophilia-focused interventions can have an immediate positive effect on reducing negative emotional states. This evidence can support the design of public health policies and programs that integrate natural and artistic experiences to improve the emotional well-being of the population, especially in urban contexts and in areas affected by environmental change.

Although the results are promising, controlled and larger sample studies are recommended to validate these findings. Individual variability and other contextual factors must be considered in order to refine interventions and to understand in depth the relationship between exposure to nature and emotional evolution.

3.4.3. Increase in positive vocalizations

The analysis of vocalizations and speech content complements the emotional evaluation obtained through the study of micro-expressions and prosodic parameters. At this point, the frequency and intensity of positive vocalizations, such as laughter, expressions of satisfaction, and surprise, are quantified. For audio analysis, tools such as open SMILE or Praat are used to identify vocal patterns associated with positive emotions, and the number and duration of episodes of laughter and other expressive sounds are recorded, comparing the moments before and after the intervention. The results indicate that before the intervention, there were "Rare laughter and expressions of satisfaction" and "Monotonous and not very expressive tone"; and after the presentation, "Notable increase in laughter and expressions of surprise and satisfaction" and "More lively and expressive tone".

3.4.4. Decrease in terms of concern in speech

The presence and frequency of terms and linguistic expressions related to environmental concern, feelings of loneliness, and melancholy were identified. Through Natural Language Processing (NLP), tools were used to analyze transcripts and extract semantic dictionaries focused on eco-anxiety and solastalgia, and the variation in the use of specific negative terms before and after the intervention was evaluated. Before the presentation, "High frequency of terms related to environmental concern, loneliness and melancholy" and "Discourse marked by restlessness and negativity" were recorded; and after the presentation, "Significant reduction in the use of negative terms" and "More neutral and optimistic language, reflecting less eco-anxiety and solastalgia".

3.4.5. Increased expressions of introspection

This word map with its respective punctuation offers a quantitative and qualitative view of the key concepts in the introspection discourse, allowing the identification of the areas of greatest emotional resonance after the biophilic and artistic intervention.

Table 5. Introspection Word Map with Punctuation. (Source by author)

Word	Score (1-5)
Reflection	5
Connection	5
Peace	5
Self	4
Serenity	4
Harmony	4
Growth	3
Balance	3
Contemplation	3
Inspiration	3
Transformation	3
Clarity	2
Wisdom	2
Integration	2
Consciousness	5

The interpretation of Table 5 indicates a high prominence (score 5) for words such as reflection, connection, awareness, and peace, as the most evoked, indicating that post-intervention participants show a strong emphasis on introspection and establishing positive bonds with themselves and their environment. Words such as self-knowledge, serenity, and harmony, of moderate-high prominence (score 4), reflect a considerable presence in the discourse, suggesting an active process of emotional balance and self-exploration. That the words growth, balance, contemplation, inspiration, and transformation appear in third place indicates that, although relevant, their frequency is moderate compared to the most prominent terms. Finally, clarity, wisdom, and integration appear to a lesser extent, which could suggest that, although they are part of introspective discourse, they are less used or less emphasized in this specific context.

3.5. Commitment to nature

As mentioned before, one of the goals of artist Duván López's exhibition is to foster greater environmental awareness and motivate participants to adopt behavioral changes that reflect a deeper connection to nature.

To assess this impact, five key indicators were measured before and after exposure in both modalities:

- Motivation to reduce the ecological footprint.
- Interest in environmental actions (recycling, reduction of consumption, etc.).
- Predisposition to changes in daily habits.
- Greater sensitivity to nature and the environment.
- Participation in collective and community initiatives.

Quantitative metrics (using a scale of 1 to 5, where 1 represents a very low motivation or commitment and 5 a high motivation or commitment) and qualitative metrics were established for each indicator, being evaluated in two moments (before and after the presentation) and in two modalities: virtual and face-to-face. This made it possible to compare the evolution in each aspect and determine to what extent the artistic experience influences environmental commitment.

Regarding the positive impact, the results show that, both in the virtual and face-to-face modalities, the five indicators experience a substantial increase after the intervention. This confirms that the artistic experience has a transformative effect on the environmental commitment of the participants.

There is an advantage of the face-to-face modality: although both modalities improve significantly, the face-to-face modality tends to have slightly higher scores in all indicators. This suggests that direct interaction with the natural environment and the physical experience of exposure can deepen the emotional and motivational connection.

Finally, with respect to the change in behavior and environmental awareness, the decrease in the ecological footprint, the increase in interest in environmental actions, the predisposition to modify daily habits, the greater sensitivity to nature, and the increase in community participation show a comprehensive transformation in the attitude of the participants. These changes translate into sustainable behaviors and greater environmental awareness. These results support the implementation of artistic and biophilic interventions in public health and environmental education programs, promoting not only greater environmental awareness but also concrete changes in sustainable habits and behaviors.

3.6. Differences between in-person and digital experiences and relate findings to potential cultural or educational policy implications.

3.6.1. In-Person vs. Digital Experiences: Emotional and Cognitive Impact

Our data indicate notable differences in how participants engaged with biophilic art depending on whether the experience occurred in-person or through a digital format. In-person experiences were associated with:

- Higher levels of emotional intensity (evidenced by stronger vocal affect and more expressive microexpressions),
- Greater spatial and embodied awareness,
- More detailed and sensorially rich verbal descriptions.

By contrast, digital interactions—while more accessible and flexible—tended to result in:

- A decrease in spontaneous emotional expression,
- Shorter or more generalized verbal narratives,
- A sense of “disconnection” or lack of full immersion, particularly among participants less accustomed to digital art platforms.

These distinctions are now discussed in light of embodied cognition theories and the role of sensory integration in emotional processing. The revised text explores how in-person experiences facilitate multisensory engagement that may be essential to fully activating the psychological benefits of biophilic encounters.

3.6.2. Policy and Institutional Implications

We have added a dedicated subsection discussing the cultural and educational implications of these findings. Specifically, we argue that:

- **Museums and cultural institutions** should continue to prioritize physical spaces that incorporate natural elements (e.g., light, organic materials, biophilic design in exhibitions) to maximize psychological and emotional engagement.
- **Digital formats** should not be seen as inferior but as complementary. However, to be truly effective, they require thoughtful design that incorporates affective and multisensory strategies—such as ambient sound, interactive visuals, or narrative immersion—to preserve emotional depth.
- **Educational programs**, particularly those focused on environmental awareness and emotional development, can benefit from integrating art that evokes biophilic responses. Programs that blend physical experience with reflective practice (drawing, writing, guided observation) may enhance both emotional literacy and ecological sensitivity.

- **Policy makers** in culture and education might consider funding initiatives that support biophilic design in schools, museums, and digital platforms, recognizing the potential for such environments to foster well-being, sustainability awareness, and inclusive engagement.

3.7 Limitations and Future Research

The present study captured the **immediate, short-term impact** of the exhibition *Biophilia and Art – Jungles and Forests* by measuring emotional and cognitive responses before and directly after exposure. This design provided valuable insight into acute shifts in eco-anxiety, solastalgia, nature connectedness, and prosocial engagement. However, it did not include longitudinal follow-up, and therefore cannot establish whether these psychological changes were **sustained over time** or translated into consistent pro-environmental or community-oriented behaviors.

We acknowledge this as a central limitation of the study. The decision to focus on immediate effects was driven by the exploratory nature of the project and by resource constraints inherent in cross-cultural and multi-modal data collection. Nevertheless, long-term outcomes are crucial for understanding whether biophilic artistic interventions can foster lasting resilience, ecological awareness, and behavioral transformation. Future research should therefore incorporate **follow-up assessments** at multiple intervals (e.g., one month, six months), compare responses across repeated exposures, and explore whether acute effects predict measurable changes in environmental attitudes, community resilience, and well-being in the longer term.

4. Conclusions

This study confirms the impact of art as a transformative tool in emotional regulation and environmental commitment. The exhibition "Jungles and Forests" has shown that both the virtual and face-to-face modalities are effective in reducing eco-anxiety (between 50% and 60%), although the face-to-face experience generates a deeper emotional transformation. This difference is due to sensory immersion that amplifies the connection with the work and the artist, enhancing introspection and motivation for collective environmental action. Establishing a clear correlation between biophilia, well-being, and art. Establishing a clear correlation between biophilia, well-being, and art, the findings align with the United Nations Sustainable Development Goals, particularly SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

Originality and Contribution to the Field, this study represents a novel contribution in several ways:

Multimodal methodology: To our knowledge, this is the first study to combine vocal affect analysis, microexpressions, natural language processing (NLP), and drawing analysis in the context of biophilic art experiences. This multimodal integration offers a more nuanced, layered understanding of emotional and cognitive responses than traditional single-method studies, addressing SDG 3 by providing innovative tools for measuring mental health benefits.

Comparative exploration of formats: The research offers an original comparison between in-person and digital encounters with biophilic art, shedding light on how format shapes affective engagement and reflective processes—a timely topic given the hybrid nature of post-pandemic cultural practices, and aligned with SDG 4 by opening new pedagogical perspectives.

Biophilia plus neuroaesthetics in real-world contexts: While theoretical connections between biophilia, art, and neuroscience have been proposed, few studies have operationalized this triad in empirical, experience-based settings. Our work bridges this gap, grounding theory in lived visitor experiences and connecting directly to SDG 11 through the rethinking of cultural infrastructures.

Focus on both psychological well-being and ecological consciousness: The study contributes to current debates about how cultural practices can simultaneously support mental health and sustainability awareness, a dual focus that remains underexplored in empirical literature, relevant to SDG 3 and SDG 13.

Practical Implications for Cultural and Educational Stakeholders. We discover concrete implications of our findings for practitioners and policymakers:

For museums and curators: The findings encourage the intentional inclusion of biophilic elements—natural materials, organic forms, representations of living systems—not only as aesthetic choices but as design strategies that enhance emotional resonance and promote psychological well-being. (SDG 3).

For educators: Educational programs that integrate nature-based artistic practices (e.g., observation-based drawing, environmental storytelling) may foster both emotional literacy and ecological empathy, particularly among young or vulnerable populations, thus contributing to SDG 4.

For digital content designers: The study suggests that digital exhibitions should move beyond static reproductions and explore immersive and multisensory formats (e.g., 360° environments, interactive soundscapes) to approximate the affective impact of in-person experiences, expanding accessibility and inclusivity (SDG 11).

For policymakers: Cultural and educational policies could promote the development of biophilic infrastructures in museums, schools, and public institutions, acknowledging their role not only in sustainability education but also in preventive mental health. (SDG 3, SDG 13).

These applications highlight the relevance of our research for shaping more inclusive, affective, and ecologically conscious cultural experiences.

The findings suggest that visual and sound stimuli play a key role in emotional perception. The combination of 100 shades of green and soundscapes in the exhibition has replicated the restorative effects of nature, inducing states of relaxation and increasing concentration. The data obtained from the analysis of prosody, facial expressions, and language used by the participants corroborate this measurable emotional transformation. In the face-to-face modality, there has been a significant reduction in emotional tension and an increase in the feeling of calm, comparable to that experienced in real natural environments. Demonstrating that exposure to nature, even in an artistic way, affects people's mental health, increasing their creativity, interpersonal relationships, and connection. (SDG 3, SDG 13).

From a neuroaesthetic perspective, the results support the theory that art activates brain circuits linked to aesthetic perception and emotional regulation. The artistic representation of nature not only evokes positive emotional responses but also modulates brain activity in a similar way to direct exposure to natural environments. Evidence suggests that integrating the color green and bird sounds into artistic experiences can enhance emotional well-being, providing a viable alternative in urban and therapeutic settings to counteract the effects of environmental stress and disconnection from nature, directly contributing to SDG 11.

The impact of the face-to-face exhibition is also reflected in a greater environmental commitment on the part of the participants. Sensory immersion fosters a stronger connection with environmental issues, generating a more pronounced intention to engage in collective actions to mitigate climate change. Although the virtual experience offers benefits in terms of reflection and anxiety reduction, its impact is more gradual and less profound compared to the face-to-face experience.

These findings have relevant implications in the design of artistic and educational interventions focused on environmental awareness and emotional well-being. The universality of the response to art, evidenced in an exhibition diverse in age and sociocultural origin, highlights its potential as a transversal tool to promote resilience in the face of the climate crisis. In addition, it opens new lines of research on the sustainability of impact over time and the role of immersive technologies in amplifying the artistic experience. The findings suggest that brief (9-minute) interventions focused on biophilia can have an immediate positive effect on reducing negative emotional states. This evidence can support the design of public health policies and programs that integrate natural and artistic experiences to improve the emotional well-being of the population, especially in urban contexts and in areas affected by environmental change.

In this study, the emotional impact of the biophilic art experience was assessed immediately following participant engagement, capturing the immediate emotional resonance elicited by the artwork. This approach allowed us to analyze acute affective responses and their correlations with vocal, facial, and verbal indicators within a controlled temporal frame. However, we acknowledge that the duration and persistence of these emotional effects were not examined, as longitudinal tracking of emotional states was beyond the scope of the present investigation. The decision

to focus on immediate responses was guided by the study's primary aim of understanding how biophilic art generates prompt emotional shifts and cognitive reflection in both in-person and digital contexts.

Recognizing this limitation, we have added a dedicated section in the Conclusion and Future Work, highlighting the importance of longitudinal follow-up studies to evaluate the sustainability of emotional benefits, potential ecological behavioral changes, and long-term cognitive reframing. Future research should incorporate repeated assessments at delayed intervals—such as 24 hours, one week, or longer post-exposure—to provide a comprehensive understanding of how biophilic art experiences might contribute to sustained psychological well-being and environmental engagement. Such longitudinal data would enrich the current findings and inform the design of interventions aimed at maximizing the therapeutic and educational potential of art grounded in biophilic principles.

This study contributes to a growing interdisciplinary understanding of how biophilic art experiences can positively influence emotional well-being, particularly by mitigating eco-anxiety and solastalgia. Through a multimodal assessment integrating vocal analysis, microexpressions, NLP, and participant drawings, we demonstrated that engagement with nature-inspired art elicits immediate affective responses that foster introspection and strengthen the connection with the natural environment. While the study focused on short-term emotional impacts, its findings underscore the potential of biophilic art as a meaningful tool for psychological restoration and environmental awareness. Future research should build on these insights by exploring the longevity of these emotional effects and their influence on pro-environmental behaviors, ultimately informing cultural, educational, and therapeutic practices aimed at promoting sustainability and collective ecological action.

In conclusion, the work carried out from the exhibition "Jungles and Forests" validates the premise that art can act as an agent of well-being, emotional restoration, and connection with nature. In a context of growing eco-anxiety, these artistic experiences offer an innovative approach to transforming environmental perception and motivating climate action. Future studies could explore the permanence of these effects over time and assess how different artistic approaches can optimize their impact on mental health and ecological engagement. These artistic experiences offer an innovative approach to transforming environmental perception and motivating climate action, fully aligned with the integrative vision of the SDGs. Beyond advancing scholarship, the results provide actionable insights for local and global socio-ecological interventions, highlighting the applied relevance of biophilic art for informing public health strategies, educational curricula, urban design, cultural programming, and climate adaptation efforts. Moreover, by reducing eco-anxiety and fostering ecological empathy, biophilic art experiences contribute to environmental risk management and enhance collective resilience, positioning culture as a key resource in preparing societies for climate uncertainty.

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Ethics approval

This study was approved by the Ethics Committee of The Wellbeing Planet Research Board, approval no. TWP-2024-07, date July 1, 2024. All participants were informed about the purpose of the study and provided consent prior to participation. The study complied with all relevant ethical standards for research involving human participants, ensuring anonymity, voluntariness, and confidentiality.

Conflict of interest

The author(s) declare that there is no competing interest.

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