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To cite this version:

Anne-Sophie Tribot, Daniel Faget, Thomas Richard, T. Changeux. The role of pre-19th century art in conservation biology: An untapped potential for connecting with nature. Biological Conservation, 2022, 276, pp.109791. 10.1016/j.biocon.2022.109791 . hal-03942992

HAL Id: hal-03942992

https://hal.science/hal-03942992v1

Submitted on 18 Jan 2023

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Title

The role of pre-19th century art in conservation biology: an untapped potential for connecting with nature

Highlights

- There is an urgent need to (i) better integrate the methods and outcomes of nature connectedness research in conservation biology, and (ii) to further study the effect of aesthetic experience on nature connectedness and pro-environmental behaviors.
- The integration of art in conservation biology and environmental education has mainly concerned post-19th century art. However, the examination of European art prior to the 19th century presents an opportunity to participate in nature connectedness through aesthetic experience, while promoting an important cultural and historical heritage.
- This approach is particularly suitable for the promotion and conservation of remote ecosystems, such as aquatic ones, to which people are generally only indirectly exposed.

Abstract

Research exploring nature connectedness has shown that these relationships influence worldviews, values, attitudes and behaviors toward nature. In this context, natural areas that are difficult to access, such as aquatic ecosystems, lead to questions concerning the need for mediation tools capable of modulating human behavior through indirect exposure. Art has been recognized as an efficient lever in this objective, as it triggers emotional, cognitive and experiential interactions. Despite a growing interest in integrating art into environmental education, prior research has mainly focused on post-19th century art. We believe, however, that pre-19th century European art presents an opportunity to connect with nature while enhancing historical and cultural heritage. We thus propose a research framework dedicated to the quantifiable study of the interrelations between aesthetic experience, behaviors, and nature connectedness (especially relating to aquatic ecosystems) using a case study approach to examine aquatic nature as represented in pre-19th century European paintings.

Keywords: nature connectedness, human-nature interactions, art, mediation tools, aquatic biodiversity

Word count: 8151 (including main text, references, and one figure)

1. The need to integrate nature connectedness into conservation biology

In recent decades, nature connectedness (NC) has been recognized as a key factor in addressing and meeting sustainability challenges (Ives et al., 2018). As one of the main levers for the adoption of pro-environmental behaviors (PEBs), NC has been shown to be a relevant tool for promoting the conservation of biodiversity (Richardson et al., 2020). An increasing number of studies suggest that NC contributes significantly to the adoption of PEBs, *i.e.* engaging in acts that benefit the natural environment and avoiding acts that harm it (Whitburn et al., 2020). In addition, NC actively participates in human happiness and well-being (Pritchard et al., 2020), and therefore concerns both ecology and human health, in line with the sustainable development goals of the United Nations.

Nature connectedness can be defined as the individual's subjective feeling of a deep and continuous awareness of the link between self and the rest of nature (Zylstra et al., 2014), and is based on multiple cognitive, sensorial, emotional and experiential dimensions (Ives et al., 2018). The evidence linking NC and PEB is mainly based on psychological theories such as the Norm-Activation-Model (Schwartz, 1977), the New Environmental Paradigm (Dunlap and Van Liere, 1978), the Theory of Planned Behavior (Ajzen, 1991), the Biophilia Hypothesis (Kellert and Wilson, 1993) and the Value-Belief-Norm Theory (Stern et al., 1999). All these theories highlight that PEBs are sequentially influenced by worldviews, attitudes, values, beliefs and personal norms (Oreg and Katz-Gerro, 2006; Dunlap, 2008; Onwezen et al., 2013; de Leeuw et al., 2015). Following these theoretical baselines, much research has been dedicated to identifying how the combination of these various factors are associated to PEBs (Li et al., 2019) and to NC (Pereira and Forster, 2015; Whitburn et al., 2020). NC and PEBs are interdisciplinary and multidimensional, so multiple self-assessment scales have been devised for their measurement (Hatty et al., 2020), based on different factors defined according to the psychological theory chosen by the authors (Barragan□Jason et al., 2022). Measuring NC and PEBs presents certain limitations: these factors are generally considered socially desirable, and participants may thus overestimate the extent to which they perform these behaviors, or the degree to which they feel connected to nature (de Leeuw et al., 2015). Moreover, if psychometric tools do allow to highlight direct correlations between NC and PEB, they do not inform causality links (Whitburn et al., 2020). The development of accurate observational tools and quantitative approaches would constitute a considerable advance in this field (Richardson et al., 2020).

In this perspective, the outcomes of previous studies linking NC and PEBs deserve to be operationally integrated and applied to the field of sustainability science, particularly in conservation biology. To make these generalist tools efficient and informative, they must be tested and adapted to specific contexts and ecosystems for which experts acknowledge the particular socio-ecological issues that need to be taken into account. Moreover, the definition of PEB deserves to be reconsidered in the light of ecological objectives as defined by conservation biology, beyond the prism of environmental psychology. The need to examine pro-nature conservation behaviors (PCBs) more precisely has recently been addressed, as prior research mainly focused on behaviors relating to climate change and resource use, at the expense of behaviors that directly support conservation of habitats and biodiversity (Barbett et al., 2020; Richardson et al., 2020; Barrows et al., 2022). It thus seems necessary to directly involve conservation biology both in response to this need and in the development of psychometric tools dedicated to PCBs.

In this context, this perspective paper aims to incite researchers in conservation biology to take part in projects carried out at the crossroads of arts and sciences. We first develop the

ways in which aesthetic experience and the beauty of nature contribute to nature connectedness. After defining nature aesthetic experience across different disciplines, we then discuss the need to integrate conservation biology into interdisciplinary research that examines the link between nature aesthetic experience and connectedness. In this context, we present Western art (in particular environmental art and Art-Sciences) as a means to promote nature connectedness and conservation. Finally, we draw attention to the lack of research exploring European historical art (pre-19th c.) in this perspective, and demonstrate through different examples the interest these artworks represent for interdisciplinary projects linking art, biological sciences, environmental education and nature connectedness.

2. Engaging with nature through aesthetic experience

2.1 Nature connectedness and engagement with the beauty of nature

Facing the current biodiversity crisis and the need to engage people with nature, research in environmental psychology has examined ways to modulate NC. A number of studies have shown that activities involving physical, emotional and sensory engagement with nature seem to have more effect on NC than do knowledge and theoretical education (Zylstra et al., 2014; Lumber et al., 2017; Ives et al., 2018; Pritchard et al., 2020; Barragan□Jason et al., 2022). In this perspective, aesthetic and experiential approaches are promising tools to improve NC through nature experiences. The beauty of nature is a fundamental aspect of the human relationship with the natural world and has been extensively studied under the prism of engagement with nature's beauty, *i.e.* experiencing positive emotional reactions in response to the perceived beauty of nature (Zhang et al., 2014). This particular aspect of human-nature interactions plays a significant role in well-being, NC, and in the adoption of pro-environmental and pro-nature conservation behaviors (Zhang et al., 2014; Barrows et al., 2022).

In a similar way, a large part of the science of environmental education has been dedicated to the mediation of biodiversity conservation through simple activities that enhance aesthetic experiences and promote engagement with nature's beauty (Barrable, 2019). Such activities include, for instance, simple exposure to nature (Barragan□Jason et al., 2022), spending some time each day noticing beautiful things in the nearby natural environment (Richardson et al., 2020), engaging with nature's beauty through artistic creation inspired by nature-based sources (Renowden et al., 2022), or viewing visual arts and performances intended to create empathy towards nature and improve knowledge about environmental concerns (Curtis et al., 2014). Facing the current general tendency of disconnection with nature (Soga and Gaston, 2016; Ives et al., 2018), several mediation tools based on indirect exposure have also been examined, revealing a positive effect on NC (Barragan□Jason et al., 2022). Regarding the low impact of theoretical education on NC, this could be linked to the method of transmitting scientific knowledge that includes neither affective nor emotional dimensions, two essential facets of NC (Barragan□Jason et al., 2022).The integration of an approach based on aesthetics and engagement with nature's beauty is thus particularly relevant in environmental education.

2.2 Nature and aesthetic experience: a multidisciplinary overview

Nature has long been a topic in aesthetic studies, and defining what is beautiful and pleasurable in nature is a knotty question that cuts across fields as diverse as philosophy, neuroscience, environmental psychology, environmental aesthetics, landscape architecture and human geography. Aesthetics relates to the human ability to judge an object from various

perspectives such as emotions, practical use, or experience (Shimamura and Palmer, 2012). At its origin, Aesthetics was a philosophical field that explored beauty through the study of sensations and emotions involving human perception, particularly by way of Art (Brady and Prior, 2020). Beauty is defined in this context as a set of perceptual qualities that generate pleasure or admiration through an aesthetic experience (Chatterjee and Vartanian, 2014). However, objects of aesthetic appreciation are not limited to works of art; indeed, aesthetic experiences triggered by nature have long aroused the interest of philosophers (Carlson, 2016). Kant, for instance, considered nature to be an object of aesthetic appreciation in itself, and introduced the notions of the Beautiful and the Sublime in nature (Kant, 1790). Beauty is associated with harmony, symmetry and order, and is therefore defined by the intrinsic characteristics of the object (Boileau, 1674), while the Sublime arouses admiration and vulnerability, such as may be experienced, for example, when confronting a beautiful landscape beyond the control of the observer (Carlson, 2000). During the 18th century, a third dimension of nature aesthetic judgement was defined: the Picturesque, which connects nature with art to treat nature and landscapes as objects of scenic pleasure (Paden, 2013). This notion greatly inspired 19th century Dutch painters, especially in their representation of landscapes (Paden, 2013).

These philosophical foundations in Aesthetics formed the background for a set of theories in environmental aesthetics beginning in the 20th century (Brady and Prior, 2020). Environmental aesthetics places the aesthetic experience of everyday environments as subject matter, in response to the field of Aesthetics that has long favored art over nature (Carlson, 2016). Environmental aesthetics particularly emphasizes the importance of the multisensory immersion of such aesthetic experiences (contrary to the visual and scenic approaches of classical Aesthetics, Berleant, 1992) and questions whether knowledge is a significant factor of aesthetic valuing (Carlson, 2000).

Research in philosophical Aesthetics has also shaped the theoretical frameworks of landscape aesthetics and environmental psychology that use an integrative approach in the attempt to identify the biological, psychological, cognitive and socio-cultural origins of the aesthetic experience of nature (see Bourassa, 1990; Kaplan, 1989; Gobster et al., 2007). Regarding the biological and cognitive underpinnings of aesthetic experience, neuro-aesthetics has also provided important insights, even though this field is mainly devoted to the aesthetic judgment of art. Ramachandran and Hirstein (1999) proposed the ‘laws of artistic experience’: a list of aesthetic perceptual qualities related to neurophysiological mechanisms. In the same vein, the processing fluency theory of aesthetic pleasure (Reber, 2004) integrated these properties into a common framework and linked pleasure to the fluency with which information flows through the cognitive system. As in neuroscience, evolutionary psychology suggests that aesthetic judgement has played a role in human survival (Kaplan, 1989). It has been hypothesized that humans have been selected throughout evolutionary history for their extreme proficiency at gathering and processing information from their environment, and that the evaluation of landscape aesthetics is the expression of a selection for simple and reliable information concerning environmental quality (Gobster et al., 2007; Kaplan, 1989).

Regarding the interdisciplinary literature in aesthetics, a historical dichotomy appears to exist between the aesthetics of art on the one hand and the aesthetics of nature on the other (Carlson, 2016; Barrows et al., 2022). However, we feel that these approaches should be considered together, because aesthetic experience is a phenomenon that concerns both art and nature. In this sense, integrating the fields of sustainability and biodiversity conservation would constitute a suitable transversal approach for the study of art, nature and aesthetic experience in a more pragmatic and operational way, which could thus be considered as a conservation lever.

2.3 The need to integrate nature aesthetics into biodiversity conservation

The interest of integrating the topic of aesthetic experience into conservation biology stems from a simple observation: affective and emotional factors play a fundamental role in the conservation of biodiversity, for we tend to protect and to invest in the conservation of what we love and find beautiful in our environment (Gobster et al., 2007; Saunders, 2013; Swaffield and McWilliam, 2013). A telling example dates from the 19th century, when landscape beauty motivated the creation of the first national parks in the United States: this initiative was greatly influenced by the painters of that time who depicted the wonders of nature (Rashkow, 2014). The beauty of nature can therefore be considered as a powerful argument for conservation, provided that the perceived aesthetic value is convergent with the ecological objectives of conservation (Gobster et al., 2007). Ecosystems with high biodiversity are generally perceived as being the most aesthetic (Tribot et al., 2018). However, this convergence is not always consistent, in particular regarding human preferences for the conservation of charismatic species (Colléony et al., 2017). Consequently, over the recent decades ecologists have examined how perceived biodiversity affects the aesthetic evaluation of species and ecosystems in an attempt to better understand how the ecology of species influences human interactions with nature and the willingness for conservation (Gaston et al., 2018). These assessments are generally based on visual and digital observations of nature (usually photographs) and very few have explored the potential for engaged and engaging nature aesthetic experiences. However, we believe that conservation biology has a role to play when investigating how different facets of nature aesthetic experience affect NC. In this perspective, there is a need to implement into conservation biology the findings of the several disciplines interested in nature aesthetic and NC. In particular, conservation biology would help formalize in this context the notions of 'nature' and biodiversity based on formal metrics, since these concepts remain fuzzy in the human sciences. It is important that the biological sciences take part in research and reflection on the relationships between aesthetic experience, NC, and conservation in order to provide an approach specifically tailored to the conservation of biodiversity. Thus, the development of interdisciplinary research at the crossroads of conservation biology, art and humanities is both urgent and pertinent.

3. Fostering nature connectedness through environmental art

Connecting people with nature through aesthetic experience could act as a lever for biodiversity conservation, revealing the need to explore experiences that trigger significant affective and emotional responses. Art is a suitable pathway in this context, because it allows to transcend the cognitive dimension of environmental concerns and also influences people's worldviews and life goals (Heras et al., 2021). Among recent successful programs connecting art with ecological mediation, many involve environmental art and exhibit a broad range of artistic practices and artworks in any format, including the use of nature as a medium. Since its appearance in the late 1960s, this artistic movement has often been characterized by a political and ethical stance towards nature (Brady, 2007; Thornes, 2008) and has aimed overall to raise awareness of environmental issues by fostering an appreciation and interest for nature. Studies in environmental education have examined the potential of such artworks and practices to foster nature connectedness through 'aesthetic learning' (arts-based educational experiences, Heras, 2022). For example, Marks et al. (2017) explored responses to environmental art initiatives in two Biosphere Reserves (Noosa, Australia and North Devon, UK) and revealed that such programs can be used both to enhance understanding of environmental issues and to generate concern. Another way to link art to environmental

education, known as Art-Science, involves using scientific data, processes or knowledge as supports for artistic projects (Lesen et al., 2016). Aesthetic learning and Art-Science initiatives are often based on participatory practices (see for example Curtis et al., 2014; Harrower et al., 2018; Renowden et al., 2022). A number of Art-Science artworks intended for large audiences have resulted from collaborations between artists, stakeholders and scientists. One such example is the Cucusonic project, that brought scientists, musicians, farmers, city dwellers and indigenous peoples together to create musical compositions based on bioacoustic recordings in Columbia (see cucusonic.net).

Obviously, artistic creation and aesthetic reception do not involve the same amount of physical commitment, but these two facets of art should be considered as complementary and reciprocal (Tinio, 2013). Although participatory approaches allow for a great degree of engagement (Lesen et al., 2016) they nevertheless have drawbacks: setting up such projects may be more costly in terms of time and resources, and their success may also be highly dependent on the motivation of the participants. Ensuing problems may include sampling bias in the recruitment of participants, or artistic practices that are not always suitable for all participants. For example, Renowden et al. (2022) reported that some participants felt 'infantilized' during a workshop where they were asked to recreate frog songs using everyday objects. Initiatives based on the aesthetic reception of artwork may be experienced by large audiences, where individuals can engage in an aesthetic experience in keeping with their own disposition and sensibilities. Regarding research into art reception (the field of Aesthetics science analyzing the factor structure of aesthetic experiences, Leder et al., 2004; Hager et al., 2012), few studies have focused on nature aesthetics, as this field mainly concerns classical art (Carlson, 2016). Further investigations at the intersection of the psychology of aesthetics, neuro-aesthetics, environmental education and sustainability sciences are therefore required.

4. Beyond environmental art: connecting with nature through pre-19th century art and cultural heritage

Art as a tool of mediation for ecological purposes has engaged the interest of artists and researchers since the late 1960s (Brady, 2007). This growing interest in art as a lever for sustainability has mainly focused on post-19th century art (Heras et al., 2021). For instance, Lesen et al. (2016) reviewed 200 Art-Science projects in the US, and found that all were based on recent artistic projects. Yet focusing only on the post-19th century period to the detriment of most of our artistic and cultural heritage seems inadequate because these earlier artworks have the potential to elicit a multitude of aesthetic responses and powerful experiences. In addition, pre-19th c. art provides an opportunity to explore the imagination of our predecessors: examining their art is a way to connect with the intimacy, daily life, and beliefs of their time. In this way, these artworks allow to confront our current relationship to nature in the face of the history of humanity and its rapport with the environment over time. Indeed, ever since humans began producing works of art (50,000 years ago), nature has been a constant source of inspiration through its intrinsic or symbolic value. There is therefore no obvious reason to concentrate research efforts on recent art only: even if a pre-19th c. artist's direct intention was not to alert to an environmental crisis, their ability to generate a strong aesthetic experience in connection with the representation of nature remains undeniable. Works of art prior to the 19th c. also constitute a cultural and historical heritage that is worthy of promotion through the prism of environmental education.

4.1 A short timeline of European art history until the 19th century

In order to provide relevant perspectives when studying pre-19th c. art in relation to nature connectedness, nature aesthetics, and conservation biology we will focus on pictorial art, particularly painting, in Western countries. Indeed, these particular artworks (among others) include many representations of nature that have survived throughout time, and they have been thoroughly studied by art historians. To explain our conviction that pre-19th c. Western art is deserving of more scientific attention, a brief timeline of European pictorial art history may be helpful.

Prehistoric art (50,000 BCE to 3,000 BCE) represents the iconographic depiction of humans and animals, whose possible symbolic and linguistic meaning is still under debate. The parietal paintings of this period testify to the fascination and the great interest of humans for the animals that surrounded them.

Ancient art (3,000 BC to 6th c. CE) is defined as the wide variety of artistic and cultural styles developed by ancient societies living during this period. The Romans, for example, represented nature and its wonders with realism, through frescoes and mosaics. Fish and aquatic animals occupy an important place in this iconography, as evidenced by the famous *Mosaic of marine life* from Pompeii (early 1st century BC).

Art of the Medieval period (6th c. - 15th c.) used symbolism to serve God. The animal was a symbolic figure to which feelings, thoughts, emotions, vices and virtues could be attributed in order to convey the teachings and morality of Christianity (Vézilier-Dussart, 2016).

The Early Modern period (15th c. to late 18th c.) includes the Renaissance, Mannerism, Baroque art, Rococo and Classicism. The art of this period is mainly figurative. Under the impetus of technical and scientific discoveries, the representation of nature and the understanding of natural phenomena became subject matter. The 18th c. Enlightenment was marked by the industrial revolution, reflecting a desire to understand the laws of nature in order to better control them. In parallel, the rise of natural theology in the early 18th c. translated the spectacle of nature into the expression of the Sublime and perfect divine creation, inspiring, for example, an admiration of the seas and oceans which had hitherto aroused fear and aversion since Antiquity (Corbin, 2018).

The Modern period (late 19th to late 20th c.), followed by Contemporary art in the 20th c., is marked by the appearance of photography and Impressionism, leading to the rethinking of the function of art: the goal is no longer to faithfully represent reality, but rather to question and criticize it, and also to reveal reality and its contradictions in a different way. During Romanticism (late 18th - late 19th c.) artists depicted pristine wilderness in landscapes charged with emotions to denounce the impact of industrialization and the desire to dominate nature. For example, Caspar David Friedrich's famous *Wanderer Above the Sea of Fog* (1818) evokes the insignificance of the human being faced with the landscape, blending admiration and incomprehension through an aesthetic of the Sublime. William Turner (1775 - 1861) painted landscapes evoking impressive natural phenomena (fire, storms, sunsets or sunrises) inspired by travels, scientific questioning and the industrial revolution. Conversely, Thomas Gainsborough's *Mr. and Mrs. Andrews* (1750) can be interpreted as an expression of land ownership and capitalist domination over nature and laborers (Rose, 1993).

In summary, pre-19th c. art figuratively depicted the history and lifestyles of civilizations in their diversity, whereas modern and contemporary art take a more reflective and abstract approach with a universal ambition.

4.2 Focus on the Early Modern period

A noteworthy example of representations of nature's beauty in pre-19th c. art is the Early Modern period in Europe (15th - 18th c.), in which artists represented the visible world with realism and fidelity (Gombrich, 2011). This period is characterized by changes in

representations of the world, by religious reforms, great discoveries and by an economic dynamism resulting from numerous innovations. During the Renaissance, arts and sciences operated harmoniously. Driven by their own curiosity, artists and scientists were often one and the same (*e.g.* Leonardo da Vinci, Albrecht Dürer, Bernard Palissy, etc.), seeking to understand nature and the world from the perspective of the wonders of nature. For this they combined scientific techniques (including the natural sciences) with beautiful and creative representations of their ideas. The discovery of the microscope in the 17th c. allowed a better understanding of nature and contributed to the appearance of naturalist painters. Among them was Anna Maria Sibylla Merian who traveled to Suriname in 1699 and brought back drawings of plants and insects integrated into their ecosystem, illustrating that a plant is not just an isolated organism, but is part of an ecosystem whose elements interact. During this period, naturalist explorations developed, and artists traveled to report their observations. Travel and discovery thus became recurring themes in 17th c. artworks.

In this way, artists and scientists used exploration and experimentation to further improve a theory, performance or work. The clear separation between the arts (related to creation and passion) and the sciences (associated with rationality) began during the 18th c. and is still ongoing today (Heylighen and Petrović, 2021). The Early Modern period is thus of particular interest when considering a reunification of the arts and sciences in the service of environmental education and NC. First, the degree of realism and the observable desire to represent reality permit a relatively reliable biological interpretation of these artworks. Secondly, the living world was treated as a subject in its own right through the emergence of animal representations in painting and the naturalistic approach, offering visions arousing wonder, curiosity, or even terror or pity (Vézilier-Dussart, 2016). This multiplicity of aesthetic responses fits perfectly within the framework of environmental education through the aesthetic experience of nature.

4.3 Science based on pre-19th c. art

Pre-19th art is generally characterized as being a testimony to past civilizations (Gombrich, 2011); it thus seems logical that scientists today are interested in these artworks in the attempt to better understand our historical connections with nature and the environmental history of living organisms. Researchers have, for example, investigated representations of fruits, flowers, vegetables or cereals in historical art in order to trace evolutionary history regarding selections over time (see for example Benzi and Berliocchi, 1999; De Smet and Vergauwen, 2021; Kazemi-Shahandashti et al., 2022). This kind of initiative, that examines botanical material from art historical sources, requires the close collaboration of biologists and art historians. The former identify the specimens represented; the latter differentiate symbolic and allegorical iconography from reliable representations that were intended to be realistic (De Smet and Vergauwen, 2021). Other research has shown the interest of historical art in understanding the environmental history of marine mammals (see for example Brito et al., 2019; Mazzoldi et al., 2019) and aquatic biodiversity (Guidetti and Micheli, 2011; Tribot et al., 2021). Finally, researchers have reflected on how painting could inform the European history of climate (Metzger and Tabeaud, 2015) and air pollution (Zerefos et al., 2014). This research has shown the importance of integrating pre-19th c. works of art as material in various disciplines in order to improve understanding of variations of the environment and living organisms over time. However, they have not explored their aesthetic reception by contemporaries as a tool for connecting with nature. Here again, we see the need for additional research at the intersection of environmental history and the psychology of aesthetics for the benefit of environmental education. Aesthetic reception could be investigated by estimating quantitatively the visibility of such works in current museums,

exhibitions and art reviews, or by conducting quantitative surveys based on psychometric questionnaires dedicated to aesthetic reception.

4.4 Connecting with nature inside and outside art museums

In this perspective, museums have a role to play in putting as many people as possible into direct contact with artworks. To achieve this, scientific mediation efforts can be proposed around cross-cutting themes such as biodiversity, allowing the public to apprehend works of art using different approaches. For example, the Anton Dohrn Zoological Station and the Capodimonte Museum of Naples recently proposed an exhibition dedicated to zoology and art history through a collection of Neapolitan Baroque still life paintings of fish and seafood (Travaglini and Santamaria, 2020). The authors reported that the paintings were effective levers of involvement regarding gastronomy and fishing, themes whose current issues of biodiversity conservation are of particular interest. The authors also stated that the use of a double narrative discourse (natural sciences and art history) as a promotional language reduced the disparities between visitors from different cultural backgrounds, and made the museum more attractive and welcoming for all. This kind of collaboration between scientists and museums is of particular interest in environmental education, since the emotional impact of the art gains strength when paired with a scientific discourse (Harrower et al., 2018). Several other initiatives based on guided tours in museums have been proposed in order to develop engaging learning activities for students by crossing art education and environmental education (see for example Inwood and Taylor, 2012). However, apart from school programs, museum exhibitions may still remain unattractive or inaccessible to the general public. Faced with this problem, it is thus important that researchers work alongside museums to develop initiatives that bring physically tangible works into general audience mediation events (such as for instance the European Researcher's Night) in order to substitute for *in situ* aesthetic experiences (Inwood and Taylor, 2012). To this end, some initiatives such as interactive shows and performances (for examples see Lesen et al., 2016) can also be exhibited outside the museums.

5. From aesthetic experience to nature connectedness: an interdisciplinary perspective to promote aquatic biodiversity conservation

Aquatic ecosystems (oceans, rivers, lakes and wetlands) represent a very pertinent concern in the context of NC through nature aesthetic experience. They aggregate strong human and ecological issues, and as such are included in the 17 Sustainable Development Goals, yet the relationships that humans have with these ecosystems are mostly derived from indirect exposure (typically through food or cultural objects). This may partly explain why perception of these ecosystems gives rise to many beliefs and misconceptions that are often disconnected from ecological realities (Langlois et al., 2022; Tribot et al., 2018).
To remediate this, there is an urgent need to find new ways to connect people with underwater worlds, which are otherwise inaccessible due to remoteness, mobility issues, lack of specific skills such as swimming, or to financial constraints (Januchowski-Hartley et al., 2020). With the exception of divers or small-scale fishermen who develop expertise and close relationships with aquatic environments (Nightingale, 2012), underwater aquatic life does not enter into most people's everyday experiences of nature. The resulting separation between human perception and ecological goals may indeed constitute an obstacle in the acceptance of conservation or restoration programs, and therefore needs to be scientifically addressed. Paradoxically however, these organisms are actually better known and viewed today than they were historically, thanks to technical advances in scuba diving and underwater cameras. We

acknowledge that the success of aquariums with the general public (Moss et al., 2017), and exhibitions about the deep ocean (e.g., the title *Wildlife Photographer of the Year 2021* was awarded to underwater photographer Laurent Ballesta) participate significantly in people's commitment to the conservation of aquatic environments. Pre-19th c. art is underestimated as an agent for connecting people with the aquatic world: here we propose indirect exposure to these works as a tool for promoting aquatic biodiversity conservation. Art may be seen in this way as an effective means of engaging with these environments and their species by indirect exposure and through aesthetic experience (Fig. 1). While we fully recognize that this aesthetic experience does not replace the true experience of nature, it does, however, enable people to interact and engage with hitherto inaccessible species and environments such as aquatic ecosystems.

In the Early Modern period, aquatic species were generally portrayed as bountiful sources of food, diversity and wonder, and were figurations of a boundless might and indomitable nature. Artworks from this period are likely to arouse multiple feelings ranging from curiosity, wonder, or appetite, to pity, disgust or unease (Vézilier-Dussart, 2016). Repulsion or disgust are generally aroused by perceptual characteristics defined as ugliness (Monroe, 1998). Although ugliness was formalized in Aesthetics during the 19th c. under the impulse of Hegel (Bancaud, 2009), the Early Modern painters had long depicted ugliness in order to sublimate reality (see for example the figures depicted by Vicenzo Campi (1536 - 1591) or Joachim Beuckelaer (1533 - 1574)). The paintings of Giuseppe Recco (1634 - 1695) for example, show kitchens and market stalls with fish and marine organisms that are ugly and perhaps even frightening due to their viscous and rough aspect (see for example *The riches of the sea with Neptune, tritons and two nereids*, 1684, by Luca Giordano and Giuseppe Recco, Fig. 1). Fishes as subjects were not considered beautiful during the 17th c., nor were they seen to be particularly interesting. The painters sublimated this *a priori* ugliness through a high degree of realism and by creating effects of light and texture: obtaining the wet reflections on the fish was a technical and technological feat. Ugliness may also be embellished by originality and curiosity: we take pleasure in seeing curious monstrosities, which are here assembled, ordered, and balanced. Finally, ugliness is sublimated by diversity, which is a principle of beauty (Esmein, 2012): in this way, painters play on the similarities and dissimilarities within the diversity of life. It is noteworthy that shellfish and crustaceans tend to be associated with travel and discovery, and figure as ornaments (see for example Pierre Mignard's *The Marquise de Seignelay and two of her sons*, 1691).

Whether positive or negative, these aesthetic responses elicit pleasure or interest and convey strong emotional, attentional and memorial implications (Menninghaus et al., 2017). Among the multitude of possible aesthetic responses, observation of these artworks today is thought-provoking and helps decipher the evolution of our perception of the environment and its resources over the long term. This increases understanding not only of the linearity of causes and consequences of human impact on nature, but also the changes of human perceptions of nature, and even prompts questions about the variation of human-nature relationships. A simple way to collect the quantitative data necessary for the in-depth examination of reciprocal relations between pre-19th c. art and NC would be to constitute a database of artworks specifically representing aquatic biodiversity (through participative science programs, such as www.biodivaquart.fr, Tribot et al., 2021). A set of analyses of the perceived effect of aquatic NC and PEB on aesthetic responses could then be applied to this corpus, using environmental psychology tools adapted to the specific case of aquatic biodiversity. More broadly, an interdisciplinary study framework based on the links between aesthetic reception (Hager et al., 2012), environmental psychology (NC and PEB) and ecology (formal identification and biological interpretation of represented organisms) would be particularly informative. To go further, partnerships between research teams and museums

would enable to test the effect of aesthetic experiences on future NC and PEBs in relation to aquatic environments through workshops consisting of guided aesthetic paths. At the same time, mediation activities outside museums involving physical media would be beneficial during events dedicated to the general public.

Note that although this article has focused on European art as a case study, art from other regions of the world also deserves to be explored through this type of approach, such as the arts of Africa, Oceania or the Americas. For instance, nature and animals occupy a central place in the iconography of the arts and crafts of Pacific Islands (Kjellgren, 2007). Its aesthetic properties are generally expressed as the receptacle of the sacred and immaterial dimensions of the living world, used as both material and source of inspiration, and thus testifying to particular spiritual connections between humans and nature (Descola, 2021). It would be of great interest to carry out cross-cultural surveys on the aesthetic reception of the arts from different regions of the world, in order to learn more about the transversality of the aesthetic experience of nature in different cultural contexts.

The development of such interdisciplinary programs represents a potentially rewarding opportunity to bring together scientists from the human and environmental sciences with actors within cultural organizations, while also involving citizens through participatory sciences. We believe this to be of great interest to conservation biology, as it is only by integrating different layers of society into research processes that the goals of improved understanding and concrete application of the links between art, human-nature relationships and behaviors in favor of biodiversity will be achieved.

6. Conclusions

Experts, managers, policy makers and ecological scientists should fully consider the arts as a viable lever for sustainable development and biodiversity conservation, and thus as a means of initiating changes in belief systems and environmental behaviors. To do this, scientific advances into the relationships between aesthetic experience, nature connectedness and pro-environmental behavior are necessary, and should not be limited to recent and contemporary artworks. We have an opportunity to better understand and quantify the interrelations between aesthetic experience, nature connectedness and behaviors, in particular with regard to environments such as aquatic ecosystems that are less accessible, and for which people's connection depends for the most part on indirect exposure. To conclude this commented review, we believe that these needs can be achieved through the promotion of research and management projects involving very broad disciplines, ranging from social and environmental psychology through the cognitive neurosciences, to art history and the environmental sciences. Finally, we recommend that pre-19th c. art deserves to be further investigated, because this is an opportunity to better understand historical nature connectedness and to foster stronger relationships with nature.

Acknowledgements

Language assistance and proofreading of this article was provided by Rachel Mackie. We thank the two anonymous reviewers for their comments and recommendations. We also thank Magali Théron, Céline Ventura Teixeira and Pierre Pinchon from Aix-Marseille University for their art history insights.

Declaration of competing interests

The authors have no competing interests to declare.

Funding sources

This work was supported by Fondation de France; Agence de l'Eau Rhône-Méditerranée-Corse; Région Sud PACA and Institut Méditerranéen pour la Transition Environnementale (Aix-Marseille University). Funding sources were not involved in the preparation of the article.

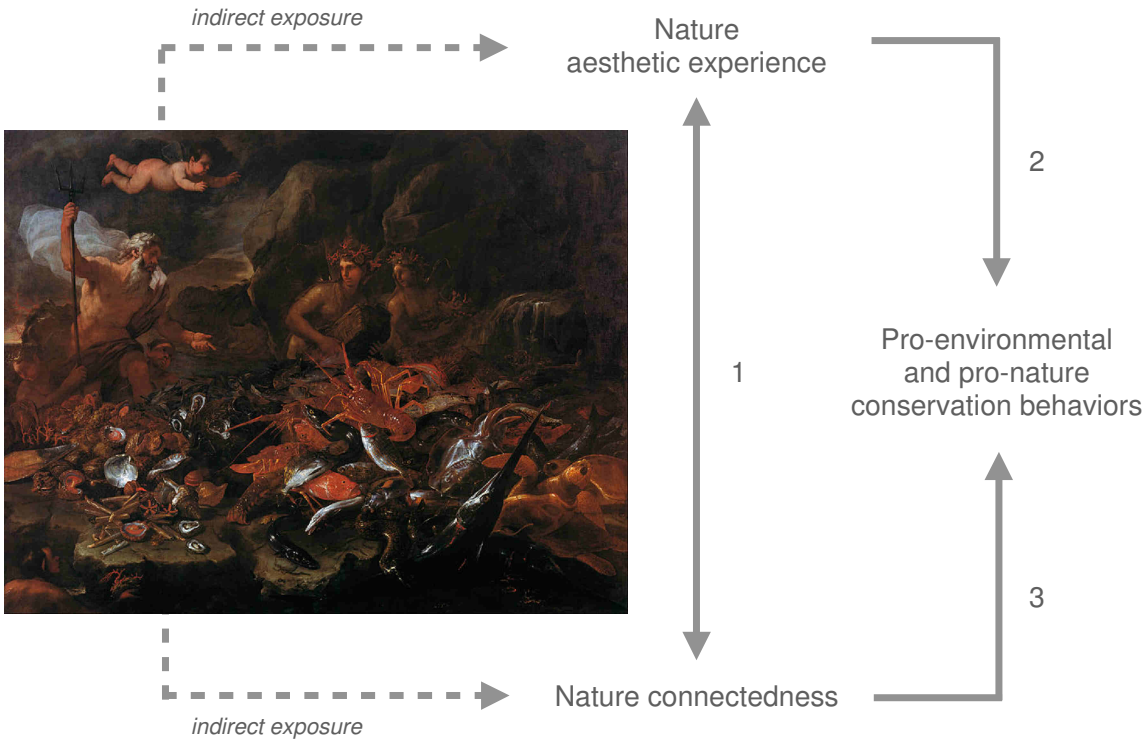

Figure 1: Art constitutes a relevant lever for enhancing nature connectedness through nature aesthetic experience. However, further examination of the effect of aesthetic experience as derived from indirect exposure to pre-19th c. art is necessary for the improved understanding of nature connectedness and pro-environmental behaviors.
Solid arrows illustrate relationships that have been well established in the literature: 1 = Barrows et al., 2022; Lumber et al., 2017; 2 = Barrows et al., 2022; Curtis et al., 2014; Lesen et al., 2016 ; 3 = Barbett et al., 2020; Richardson et al., 2020; Whitburn et al., 2020.
Dotted arrows represent hypothesized relationships requiring further investigation: the effect of such paintings on NC, PEB and PCB could for instance be examined through questionnaires using the Art Reception Survey (*e.g.*, Hager et al., 2012), NC scales (*e.g.*, Hatty et al., 2020) and PEB/PCB scales (*e.g.,* Barbett et al., 2020). Through a quantitative approach, statistical relationships between these factors could be modeled.
Painting: Luca Giordano, Giuseppe Recco, 1684, *The riches of the sea with Neptune, tritons and two nereids,* Naples, oil on canvas, 296 x 234 cm, Art Gallery of South Australia.

Source: Google Arts & Culture, US Public Domain Mark 1.0 - CC0, Mary Overton Gift Fund 1997, Art Gallery of South Australia.

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