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Aesthetic assessment of the landscape using psychophysical and psychological models: Comparative analysis in a protected natural area

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HIGHLIGHTS

- Psychophysical and psychological models produce diverging results.
- Both models tend to coincide in positive ratings location.
- The psychological model generates better ratings than the psychophysical.
- Places visited by users tend to be better rated than places not visited.

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ABSTRACT

In this article we compare two traditional aesthetic landscape assessment models, the psychophysical model and the psychological model. Our aim is to determine how close both theoretical frameworks are and to what extent they produce similar results, both thematically and spatially. We conduct the psychophysical model using a mapping procedure based on the use of geographic information systems, and the psychological one through a public participation geographic information system, and compare both using spatial analysis techniques. The results indicate that the two models produce divergent results, although both tend to coincide in locating positive ratings. The psychological model generates more and better ratings. Also, a correlation is revealed between the places visited by the users and the places with the best assessment. The main reason for the divergence between the two models is their different rationale. Neither model must be understood as a replacement for the other, but rather as a complement to each other, because together they generate information that cannot be provided separately.

1. Introduction

The most usual approximation to the aesthetic quality of the landscape tends to be through its visual dimension. It is thought that the perception of landscape through vision effectively synthesizes the state of its elements, the impression it creates and, ultimately, the evaluation that it is carried out (Lothian, 1999; Tveit, Ode Sang, & Hägerhäll, 2018). The way the landscape is understood is fundamental for its rating, for its inclusion in public policies, planning and well-being (Pérez Albert, Azuara Garcés, Giralt González, Márquez de Bishop, Saladié Mañé, & Vallina Rodríguez, 2015; Sahraoui, Clauzel, & Foltête, 2016; Subiza-Pérez, Hauru, Korpela, Haapala, & Lehvävirta, 2019). The aesthetic assessment of the landscape plays a key role in providing ecosystem services, although their complexity makes it hard to include the assessment in specialized studies and it is not always represented enough or conveniently addressed (de Groot, Alkemade, Braat, Hein, & Willemen, 2010; Dronova, 2019).

The aesthetic assessment of the landscape is linked to its degree of excellence, how it is established in relation to other landscapes, and is understood to be an estimate of its attractiveness (Daniel, 2001; Ode, Tveit, & Fry, 2008). Traditionally, distinction has been made between an objective approach to aesthetic rating and a subjective one (Daniel, 2001; Lothian, 1999). The objective approach understands that aesthetic quality is inherent in the elements making up the landscape

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and that, consequently, it is independent of the observer's judgment. On the other hand, the subjective approach considers that the landscape's aesthetic quality lies in the rating given by the observer and that, therefore, it is a construct of each individual. In the first case, it is assumed that beauty lies "in the observed element", while in the second case it is understood that beauty is "in the eye of the beholder".

The objective paradigm focuses on biological, ecological and formal aesthetic elements, and emphasizes the landscape's physical structure; the subjective paradigm is based on psychological type criteria, which comprise cognitive and phenomenological aspects, and it focuses on the observer's reaction to the landscape. The transition between the first framework and the second is gradual. Daniel and Vining (1983) distinguish five approaches: (1) the ecological model provides a reference to the quality of the landscape defined by ecological and biological elements and it is independent of the observer; (2) the formal aesthetic model fixes its attention on the formalism elements, such as the unity, direction or composition of elements; (3) the psychophysical model looks for the relationship between physical elements in the landscape and preferences of the average observer, and to this end it is based on photographs, representations and cartographic sources; (4) the psychological model focuses on the observer's cognitive, affective and evaluative rating based on their experiences; finally, (5) the phenomenological model focuses its attention on the way that each individual interprets the landscape and gives importance to certain attributes or configurations according to their individual experiences.

Other arguments go in-depth into these models, and generalize them or break them down, and reflect upon their origin and connection, on the relative importance they confer on the landscape and the observer, or discuss their possible economic rating (Kaplan & Kaplan, 1989; Tuan Topophilia, 1974; Tveit et al., 2018). Although all the approaches are lawful, Daniel and Vining (1983) indicate that the most useful and trustworthy approaches are those that are supported by psychophysical and psychological premises. This is because these models are halfway between the objective and the subjective paradigm, they are balanced and solid, have an integrating nature and consider appreciations that can be generalized to a certain degree.

Several works compare different approaches or methodologies for addressing the landscape; the polysemy of this term and its patency lend itself to this. For example, Otero Pastor, Casermeiro Martínez, Ezquerra Canalejoa, and Esparcia Mariño (2007) compare an *in situ* landscape evaluation procedure with another one that is *ex situ*, and collate the pros and cons of working with information collected first hand in the field with data processed in a desk study using geographic information systems (GIS). The authors note that both methods provide similar results and conclude that, if the spatial bases used are sufficiently detailed and true, and if the expert knowledge is appropriate, the *ex situ* procedure has the additional advantage of saving working time. Another example comes from Serrano Giné (2014), who relates delimiting units of synthetic landscape with irregular geometry against analytical units with regular geometry. The compared results of the study suggest that on a small scale both procedures generate similar units, while on a large scale, they offer divergent delimitations. The work by Gao, Liang, Chen, and Qiu (2019) compares the results of landscape preferences using three procedures: *in situ* interviews, photography comparison and the use of virtual reality. The authors did not notice different responses according to gender or profession, but they did notice differences depending on the rating method used. So, the opinions of participants addressed through *in situ* interviews and photography comparisons were relatively similar, while the opinions of those questioned using virtual reality offered noticeably different ratings. The authors underline the importance of the procedure used to assess landscape preferences, as different methods can imply different results for similar groups. Other works comparing study methods focus on quantitative approaches based on the use of indices, fractal calculations, landscape metrics or crowd-sourced data (e.g. Chien, Carver, & Comber, 2021; Fan & Myint, 2014; Vojteková & Vojtek, 2019). However, we do not know of any prior experiences that have compared objective and subjective approaches systematically, or which have focused on comparing aesthetic landscape assessment models. The objective and subjective approaches depart from different rationales, are built on different bases and yield different results, though both delve into the same topic, approach the same subject and share common grounds. As far as we know, the complementarity between these theoretical frameworks has not been explored sufficiently, and we think that there is an absence of studies analyzing the parallel relationship between aesthetic landscape assessment models according to the classic classification provided by Daniel and Vining (1983).

The aim of this paper is to: (1) compare the psychophysical and the psychological models that Daniel and Vining (1983) define for aesthetic landscape assessment, and (2) explore how both approaches complement each other. Due to their balance and solidity, these two models are the ones considered most appropriate for conducting this type of assessment and we believe that a comparison between the two can provide some significant advances in landscape theory. We have organized the manuscript into six sections: after this one, we go in-depth into the two models indicated and refer to interesting experiences that have developed them; in the third section, we set out the general aspects of the study area and the procedure followed and, in the fourth section, we show the results obtained. The discussion is in the fifth section and it is structured around the complementary nature of both procedures. Finally, the article closes with a conclusion section.

2. Conceptual framework

The psychophysical and psychological models simplify the transition between the objective and subjective paradigms by Daniel and Vining (1983). Although it is easy to present them individually, their behavior is not always obvious since they often become integrated, both with each other and with other models.

The psychophysical model focuses on detecting the relationship between physical elements, such as the relief of the land or the vegetation, and the preferences that they arouse in the observer. For this, researchers use territorial representations or inventories, which can take the form of photographs, drawings or cartographic layouts, and the reactions that apparently an average observer usually experiences. The justification of preferences is usually based on expert criteria or psychological-type generalizations. Although a heterogeneity of responses is recognized according to groups (Scott, 2006), responses usually assume a universal character that makes it easy to establish generalizations (Sarnowski, Podgórski, & Brykala, 2016). So, commonly, water bodies, height differences, developed vegetation, traditional crops or mosaic matrices receive positive ratings (e.g. Gómez-Limón & Fernández, 1999). GIS tools and Multi-Criteria Assessment (MCA) make it possible to scrutinize territorial inventories in a systematic way, and specific algorithms such as viewsheds notably enrich these exercises (Sahraoui et al., 2016). There is a long list of studies of this kind (e.g. Martín Ramos & Otero Pastor, 2012) which must be understood as spatial models aimed at detecting the potential aesthetic quality of the landscape (Pérez Albert et al., 2015).

The psychological model revolves around the opinions and judgments formed by the observer based on their experience in a certain landscape. The ratings considered are of cognitive, affective or evaluative type, and they are conveyed through variables such as the naturalness, legibility or complexity of the landscape. The justification of the preferences is eminently subjective and it is related to the observer's experiences in a certain landscape and the way that these have been coded psychologically in a certain situation (Coeterier, 1996; Kaplan & Kaplan, 1989). A large number of experiments in this respect are known (e.g. Perovic & Folic, 2012), which tend to highlight the integrating nature of the ratings. This way, the judgments issued by the observer synthesize the impressions produced by the landscape and combine, within an opinion, various aspects that are related in different proportion to the landscape assessment variables. Owing to their nature, the results obtained are difficult to generalize, but they have a holistic character and enable us to establish relative valid trends for average observers and for one and same area of study. This means that these works are particularly interesting for estimating the influence of certain landscapes on the well-being of their users (Tomao et al., 2018), in order to assess familiarity and territorial attachment (Menatti, Subiza-Pérez, Villalpando-Flores, Vozmediano, & San Juan, 2019), or to study aesthetic evaluation in an evolutionary way (Subiza-Pérez et al., 2019).

Both models are based on different premises, even though to a certain extent they can be considered coalescing. The psychophysical model focuses on detecting easily measurable and quantifiable physical variables, and aims to generalize the aesthetic-based judgments formed about them. The psychological model correlates cognitive, affective and evaluative reactions, and aims to define and explain the opinions that the landscape arouses in observers. The first model assesses each element of the landscape separately and is universal; the second supports a holistic concept, because it considers all the elements together. This way, the claimed overall aspect and analytical character of one model offsets the spatial specificness and synthetism of the other. There are numerous studies that look for points of convergence in landscape preferences (e.g. Tveit et al., 2018; Van Zanten, Verburg, Scholte, & Tieskens, 2016), or which examine aspects of consensus and incorporate biophysical variables into psychological analysis, and vice versa (Karasov, Vieira, Külvik, & Chervanyov, 2020; Urbis, Povilanskas, & Newton, 2019), but we do not know of any work that compares the results obtained from both approaches, and which makes it possible to establish their similarities and differences.

3. Methodology

The methodological development is based on using GIS, with different working procedures for the psychophysical and the psychological models, and applying spatial analysis techniques and expert knowledge. The calculations have been done with ArcgGis 10.2 software, considering a cell size of 25 m side, with a final cartographic scale of 1:50.000. The territorial validation has been conducted in the Ebro Delta Natural Park (Spain).

3.1. Area of study

The Ebro Delta covers a surface area of more than 330 km^2, is mainly covered by rice fields, lagoons, marshland and wetlands, and it is considered one of the main wetland areas in the western Mediterranean (Generalitat de Catalunya, 2021). The area is protected by the Natura 2000 Network, the UNESCO Man and Biosphere program, the RAMSAR Convention and the Natural Park status, and it includes six natural reserves where human activity is limited (Fig. 1). More than 150,000 people visit the place every year, and the park managers are particularly sensitive to developing activities regarding information, environmental education, public use and sustainable practices (Jurado Rota, Pérez Albert, & Serrano Giné, 2019; Generalitat de Catalunya, 2021).

3.2. Psychophysical model

The aesthetic landscape assessment according to the psychophysical model is based on taking prior experiences focused on using GIS and MCA (multi-criteria analysis) (e.g. Vizzari, 2011) as a reference. The layers of information used have been obtained from official information sources and have been organized into three sections, according to whether they serve the landscape's intrinsic quality, elements of positive incidence or elements of negative incidence, following a procedure used successfully on other occasions (Pérez Albert et al., 2015). In a first approximation, a total of 54 layers of information were selected, but following various assays, these were reduced to 17 as they provided similar results in a more simplified way. The cartographic development

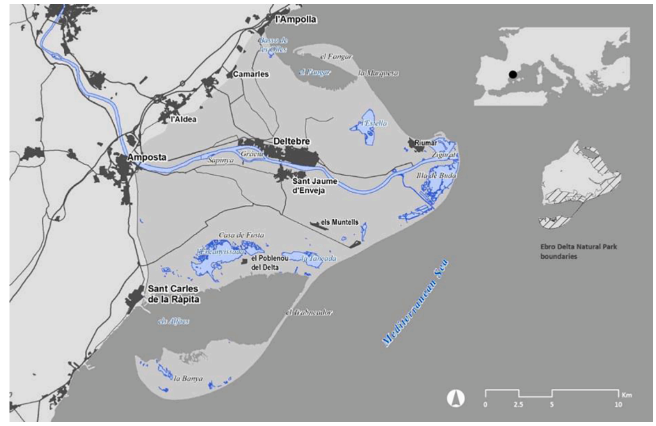

Fig. 1. Area of study. Source: Map derived from the Topographic Map of Catalonia 1: 50.000 of the Institut Cartogràfic i Geològic de Catalunya (ICGC), used under a CC BY 4.0 license.

was achieved using operations of weighted overlay, with mobile windows of 3x3 cells being used for neighborhood operations, and areas of immediate (<2.5 km), average (2.5–5 km) and far (5–15 km) scope being used for visibility calculations, according to the characteristics of each element.

The intrinsic quality has been defined according to the land relief, vegetation and soil occupation. Following works referring to the use of this procedure (Aramburu Maqua, Escribano Bombín, López Hernández, & Sánchez Ramos, 2015; Martín Ramos & Otero Pastor, 2012; Otero Pastor et al., 2007), the altimetry difference, vegetation physiognomy, vertical development and seasonal coloring have been rated positively, together with the presence of water bodies, land cover diversity and the characteristics of artificial and agricultural covers. The weightings used for each layer are summarized in Table 1.

The elements of positive incidence include highlighted beaches, monumental trees, singular land relief formations, heritage elements, viewpoints, the proximity to water bodies, salt flats and the pink flamingo breeding area. The elements of negative incidence were considered to be wastewater treatment plants and roads, ranked in primary and secondary types. A matrix has been calculated for all these elements, both positive and negative, which relates their proximity and visibility and weights their influence in the environment according to a descending monotone curve. This procedure is based on assuming the influence that those elements have in their context (Subiza-Pérez et al., 2019; Van Zanten et al., 2016), and assigns greater weighting to the closeness of positive elements and the remoteness of negative elements. The elements with positive incidence took precedence over those which had negative incidence; the weightings used are summarized in Table 2.

The final result, the value of the visual landscape quality (VLQ), is obtained through the following formula:

$$VLQ = A + 10\%B - 5\%C$$

Table 1
Intrinsic value of the landscape. Layers of information and weighting.

Subcriteria	%	Criteria	%	Aim	%
Altimetry difference	20	Natural/Semi-natural elements	70	Intrinsic visual quality (A)	100
Type of vegetation	30				
Vegetation layers	10				
Sheets of water	40				
Artificial and agricultural covers	70	Artificial and agricultural elements	30		
Diversity of occupation	30				

Table 2
Elements of extrinsic incidence. Layers of information and weighting.

Subcriteria	%	Criteria	%	Aim	%
Highlighted beaches	25	Natural/Semi-natural elements	65	Positive incidence (B)	(+) 10
Monumental trees	10				
Geomorphological interest	30				
Sheets of water	20				
Pink flamingo observation	15				
Elements with patrimonial value	15	Artificial elements	35		
Viewpoints	50				
Salt flats	35				
Water treatment plants	30	Artificial elements	100	Negative incidence (C)	(−) 5
Main communication routes	40				
Secondary communication routes	30				

Fig. 2. Screenshot of the PPGIS questionnaire used to gather information.

where VLQ is the visual quality of the landscape; A the intrinsic value, B the elements of positive incidence and C the elements of negative incidence.

A panel of experts in the study area helped to integrate and weight the variables, both those referring to the intrinsic quality and to positive and negative incidence. This panel was made up of technicians from the natural park (4), from the biosphere reserve (4), and from a travel agency specialized in ecotourism (1). They were requested to rank the importance of variables and were asked to comment on them or on other variables that will be interesting for the aesthetic appreciation of the landscape. The results were integrated using a hierarchical weighting, whereby the sum of the weight ranges is determined by the individual ranges, and is standardized by dividing by the sum of the ranges, according to Yajure Ramírez (2016).

3.3. Psychological model

The aesthetic assessment of the landscape according to the psychological model has been conducted using an online Public Participation Geographic Information System (PPGIS). The participants were requested to locate their degree of attraction and interest in the landscape, and to rate it on a scale of five points, where the maximum value (+2) corresponded to very positive and the minimum (−2) to very negative. In order to obtain a better representation on the PPGIS interface, each category was associated to a color grading from green to red. The participants also had the opportunity to expand their feedback by adding comments to their ratings. This procedure is based on selecting and categorizing opposing pairs of adjectives, which is a traditional selection method initially proposed by Osgood, Suci, and Tannebaum (1957) and developed for open spaces by Perovic and Folic (2012). The PPGIS exercise was designed to be operative in the Google Maps application, and required that the participant had certain spatial knowledge of the area under study (they were asked the number of times that they had visited and the time since their last visit). Just like in Google Maps, it was possible to view the study area using a topographic map or an orthophotography, activate place-name labels and use the Street View application. By default, the questionnaire started viewing the study area as a whole, which was equivalent to a graphic scale of 5 km according to the program interface. In order to guarantee the accuracy of the locations, the user was required to zoom into to a scale of 1 km or more. The questionnaire instructions did not make it mandatory to assign a minimum number of locations, but participants were encouraged to make as many contributions as they wanted. Fig. 2 shows a screenshot of the questionnaire.

A total of 276 questionnaires were collected, out of which 80 were discarded because they were incomplete or contained spatial errors. The result was 1,593 georeferenced opinions, which is a mean rate of 8.13 opinions per participant. Out of these, those that did not refer specifically to the attractiveness and interest of the landscape were eliminated, so as to work only with the judgments of the landscape's aesthetic value (89.90%). Over half of the participants (55%) were women, 37% men and the rest (8%) did not identify themselves. The youngest respondent was 15 years old and the oldest 55; the respondent mean age was 27.26 years. The most active group was the group 20–29 years (49.23% of the input); respondents under 35 years old represented 81% of all the answers. Some respondents also added comments to their opinions, 149 comments were reported by 45 users (48.65% women, 43.24% men and 8.11% not identified; mean age 29.59 years). The information gathered was interpolated spatially using the IDW algorithm, which weights sampling points by considering their thematic value and spatial location. This algorithm assumes that sample points influence decreases as their distance increases (Burrough & McDonnell, 1998). The resulting interpolation surface produces a reliable spatial pattern that depicts user's opinions where participants expressed their views, and infers realistic scores where they did not do so. For the interpolation, tests were done with 12, 18, 20 and 25 sampling points; finally, a value of 18 was chosen for generating smooth, reliable surface areas. A posteriori analysis was conducted to test the skewness of the interpolation surface. Clusters of data, which were assumed not to produce interpolated outputs, were compared against the entire interpolated surface. The result depicted the same pattern and trend, and translated into a mean difference of 2.91% between the non interpolated surface and the interpolated one, which means high confidence in the interpolation procedure.

3.4. Comparison between models

Both the psychophysical and the psychological model were structured on qualitative legends organized into five categories. As both exercises were based on different information sources and different procedures, the minimum and maximum values of their respective ranges were not directly comparable. In order to ensure the effectiveness of the comparison, it was necessary to standardize the values of each layer of information according to a common range, where the value −2 corresponded to very low ratings, the value −1 to low ratings, the value 0 to average ratings, the value +1 to high ratings and the value +2 to very high ratings.

The comparison between both models was done using spatial analysis and cell statistic operations. Consideration was given to the maximum difference, the minimum, the range and the standard deviation for the two models to be analyzed. Also, local analyses were conducted to detect the locations with equal, greater or lesser frequency recurrence. A qualitative approach was also conducted in six sites using expert knowledge and benefiting from user's comments reported in the PPGIS questionnaire. Three sites were selected for having the higher rating in the comparison and three for having the lowest; sites selection was prioritized according to their extension.

4. Results

The two models analyzed produce divergent results for the same study area. The psychophysical model tends to prioritize low scores, whereas the psychological favors high ones. The judgment grading was not symmetrical either: the psychophysical model judges the largest part of the study (66.19%) to have a low quality, while the psychological model considers that a similar percentage (59.97%) has a very high rating. Table 3 shows the results for both models per category, and Fig. 3 represents them cartographically.

In statistical terms, the places that the psychological model tends to rate as high or very high quality, are usually given an average or low rating by the psychophysical model. The range differences (54.26% for the average category and 35.04% for the low) confirm this pattern. Table 4 shows key local statistics, calculated taking as reference 25 m side cells, per category and for both models. Overall, the surface areas rated equally by the two models are the least frequent, as indicated by the standard deviation analysis (28.09 km^2).

From a spatial point of view, irrespectively of the model used, 97.06% of the surface area is always rated positively, although to varying degrees. The surface areas constantly judged negatively barely total 3.5 km^2, and they are mainly considered to have a low quality. The frequency recurrence analysis is consistent with the statistical approximation. This way, in 98.77% of the study area, a rating change is registered between the two models, that leaves 3.97 km^2 of the Delta without any approximation differences. In practice, in all cases (98.55% of the surface area), these changes suggest a better rating by the psychological model (Fig. 3).

As for chorology, the rationale of the psychophysical model generates more fragmented distributions than those of the psychological model, because of land cover distribution, which has a prevalent weight on the development of the model. The compactness of the distributions in the psychological model is explained by the nature of the judgments analyzed and the interpolation process, which generates smooth anisotropic surface areas. Overall, the spatial distribution of the psychological model produces more compact and homogenous patterns than the psychophysical one.

In terms of regions, the places with more stable ratings coincide with urban areas and tourist attractions that are rated negatively in both models, albeit to a varying degree. The positive ratings show more dynamic behavior and coincide with some beaches, lagoons and nature reserves, yet the delimitation proposed by both models is not equal. If we take the psychological model as a reference, for most of the locations the comparative analysis implies a change in the geometry of the zones and an increase in three categories in the legend (Fig. 4).

The spatial correlation between the location of judgments and the areas given maximum scores by both models, reveals a coincidence of 70.82% in the opinions (99% of which give a "very high" rating). In other words, almost three quarters of the opinions (mainly with a "very high" rating) are located in places that both models consider to be of maximum quality.

On the other hand, the spatial correlation between the judgments

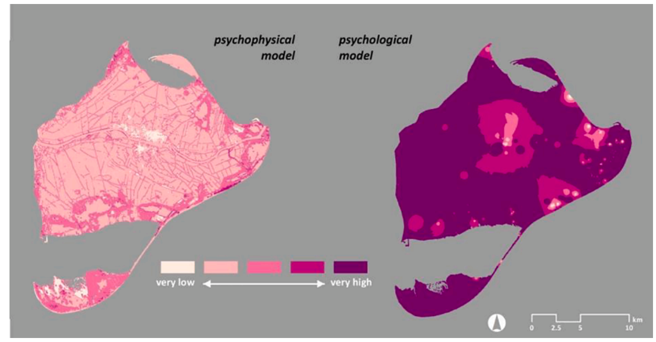

Fig. 3. Aesthetic landscape assessment using the psychophysical and psychological models.

and the differences between the two models, show that 76.56% of the opinions (63.85% of which are "very high" ratings) coincide geographically with places that the psychological model rates two or three times better than the psychophysical. This trend is expressed more clearly if the judgments are correlated with the statistical deviation between both models, as 80.58% of the georeferenced opinions (83.66% of which have a "very high" rating) coincide with areas that are one or two points away from the spatial mean of both models.

A site level approach was conducted in three sites with the highest rating (sites 1–3) in the comparison analysis and three sites with the lowest (sites 4–6). Table 5 provides a brief description of each site and Fig. 5 shows their location and photograph.

Urban settlements are better rated in the psychological model than in the psychophysical. An analysis of respondent's origin reveals that local users tend to report higher scores than non-local users. For example, respondent 91 (local, 18-year-old female) defines Deltebre (site 1) as "lovely town worth visiting with genuine people who know how to enjoy life" whereas respondent 31 (non-local, 32-year-old man) refers to this same town as "ugly place". High scores are also given to places where valued landscape features such as water bodies, heritage items and flamingos occur. However, a spatial overlay reveals that not all places with such features are well rated. Some places such as Sant Antoni salt panes (site 2), where there is an environmental information center, stand out from the rest. Respondent 36 (31-year-old man) describes it as "simply amazing", and respondent 54 (27-year-old man) as "silent place with a lot of natural charm". Some other places with similar features are also well rated, even if they are reserves and the general public are not supposed to access them. Punta de la Banya (site 3) is a natural reserve where human access is restricted, about which respondent 198 (49-year-old man) comments: "a magic place, a unique and simple landscape with no more than sand and sea".

Places where negative impacts or degraded environment occur tend to be rated worse in the psychological model than in the psychophysical one. For example, Lower Marquesa Beach (site 4) is a popular spot known for being badly eroded by the ocean swell and it has been used as an example of the precarious stability of coastal areas. Respondent 16 (36-year-old man) says "the restaurant should be removed because it's not natural, and people don't care for the environment". Tourist resorts are also badly rated; some people report lack of landscape integration or aesthetic criteria. For example, respondent 54 (27-year-old female) says "tourist resorts spoil the charm of the place and don't match with traditional architecture", and respondent 1 (36-year-old female) says

Table 3
Aesthetic landscape assessment rating using the psychophysical and psychological models (data relating surface area).

	Very low		Low		Average		High		Very high	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
Psychophysical model	10.90	3.36	214.72	66.19	94.68	29.19	3.88	1.20	0.21	0.07
Psychological model	0.13	0.04	0.91	0.28	13.99	4.31	114.91	35.44	194.46	59.97

Table 4
Aesthetic landscape assessment rating using the psychophysical and psychological model (data regarding surface area).

	Very low		Low		Average		High		Very high	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
Maximum value	0.02	0.01	0.71	0.22	8.83	2.72	55.82	17.21	259.02	79.85
Minimum value	11.13	3.43	214.88	66.24	94.37	29.09	3.83	1.18	0.19	0.06
Range difference	24.11	7.43	113.65	35.04	176.00	54.26	6.65	2.05	–	–

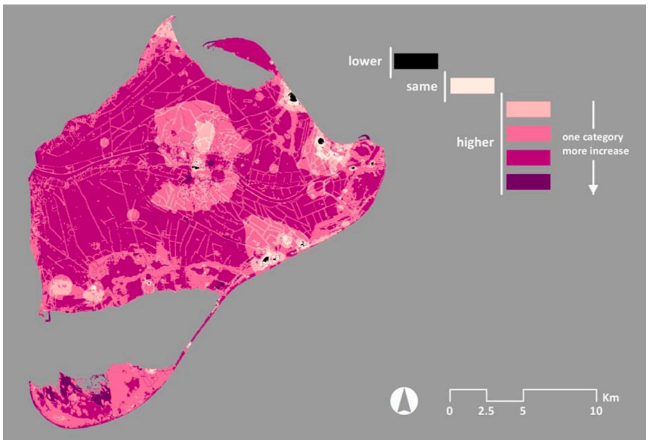

Fig. 4. Differences between ratings using the psychological model and the psychophysical model.

Table 5
Description of sites with the highest (1–3) and the lowest (4–6) rating.

Site	Description
1. Deltebre	Settlement made up by low density urban fabric. Most of the buildings are terraced houses, usually of less 10 m height. Sant Miquel de la Cava church (1818) is a lively spot in town.
2. Sant Antoni salt panes	Salt panes harvested until the second half of the XX century, now used as environmental information centre to show traditional fishing and salt harvesting techniques. Flamingos can be seen in the area.
3. Punta de la Banya	Inner side of a peninsula covered with dense salt meadows and small pools. A lighthouse stands at the centre of the site. Inland hills appear in the background and create scenic views. This site is a natural reserve where human access is regulated.
4. Lower Marquesa Beach	Eroded cuspate foreland. A degraded building used as a restaurant stands in the centre of the site, some rice cultures and areas with bare soil or sparse vegetation lay at the back of the building; a rock barrier has been built seawards to control erosion. The whole area is exposed to the ocean swell, and items washed up from the sea and poached soil occurs. This site neighbours a natural reserve with dune-slacks where human access is regulated.
5. Riumar resort	Touristy resort recently redeveloped. The area stands between some dunes near the sea and salt meadows in the hinterland. The south and central section of the resort is in a low density urban frame whereas the north section is sparsely built up and lacks paved roads.
6. Eucaliptus resort	Touristy resort. The area stands between some rice fields and a wide exposed beach which, in some areas, is partially covered with poached salt meadows.

"this place would be pleasanter if it were clean". Other comments stress the use of the place rather than its configuration: respondent 4 (30-year-old man) notices "the beach is full of litter washed up by the sea, stranded by the wind or left behind by the tourists themselves", respondent 110 (33-year-old man) says "[this beach] in summer is crowded and the number of beachgoers should be regulated", and respondent 9 (26-year-old man) says "too many people in such a small place, too many beachgoers and cars in the same place".

5. Discussion

This article compares the psychophysical and the psychological model for aesthetic landscape assessment, and explores the similarities and differences of both approaches in the Ebro Delta. The comparison between the two models reveals divergent results: the psychophysical model provides low ratings and the psychological high ones. Below, we reflect upon the reason for this discrepancy.

5.1. Divergences between the models

The psychophysical model focuses on detecting and weighting physical landscape elements and, in the way that we have developed it herein, it is similar to a usual map-based procedure. Just as Otero Pastor et al. (2007) warned, the effectiveness of these works lies in the quality of the spatial bases used. Generally speaking, we can affirm that if the reference categories are good, the results are also good. By weighting variables, it is possible to systemize the complexity inherent in this kind of ratings. Vizzari (2011) provides an interesting example by integrating physical-naturalistic, historical-cultural, and social-symbolic elements, and suggests that using weights in cartographic procedures not only contributes to interpreting elements individually, but also improves the accuracy regarding their contribution to their surrounding context. In this respect, our experience warns of a possible common deviation in this kind of work. Frequently, the researcher shows a tendency to combine the largest possible number of reference maps, without realizing that many layers of information are redundant and that their overall involvement can be simplified by using weights. Regarding the MCA procedure, it may be argued that a different panel of experts might have come up with a different weighting and hence produced different results. We believe that the pretty high number of experts (9) and their heterogeneity assures a balanced weighting. Therefore, it would have followed a similar pattern to the current one.

The rationale behind the psychological model is different, as it is based on the judgments formed by users according to their background and experience. For example, the site-level approach demonstrates that respondents give lower rates when they associate a given place to a poor visitation experience, for example on beaches in tourist resorts (sites 5 and 6). A frequent criticism of this kind of ratings is the reduced number of participants on whom the results are based, whereby sometimes they can be considered to lack representativeness. However, this fact must be interpreted carefully, as a greater number of participants does not suggest a greater representation of opinions. For example, in his pioneering study on the Dutch landscape, Coeterier (1996) affirms that after six or seven interviews with informants, they did not provide any new information and that, consequently, their opinions could be assumed to be representative of the population as a whole. One aspect that is possibly more important is the spatial bias that may be associated to participants and opinions. Avila Callau, Pérez Albert, Jurado Rota, and Serrano Giné (2019) present an illustrative case. In a study on the characterization of the landscape based on photographs on social media, they noticed that 55% of the images analyzed were taken from paths or near them and that, consequently, the accessibility to certain landscapes favored their prevalence in the perceived image. This way, the landscape that is assumed as the most representative is not the most abundant, but rather the most accessible. The site analysis also seems to point to this fact: a case in point is site 2, which is a highly visited place and easy to access.

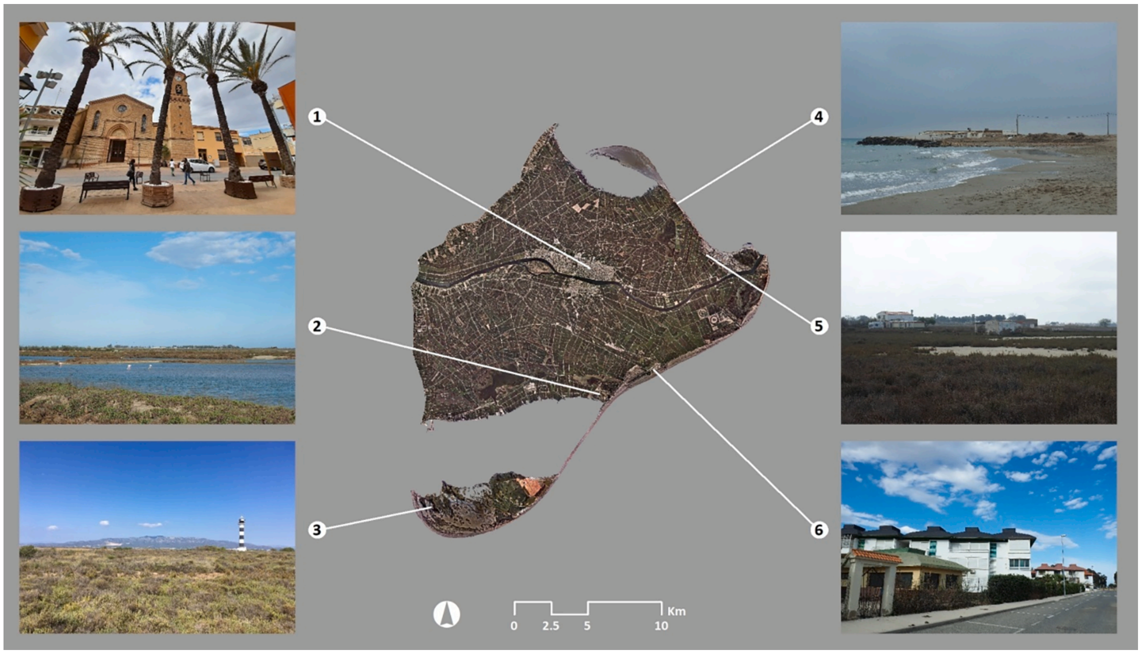

Fig. 5. Location of sites. Number of sites correlates with those in Table 5. Sources: pictures, the authors; map, Orthophoto of Catalonia 1: 50.000 of the Institut Cartogràfic i Geològic de Catalunya (ICGC), under a CC BY 4.0 license.

Our exercise reveals a divergence between the two models analyzed. Although both models generate differences according to whether they approximate positive or negative ratings, the places rated positively vary less than those rated negatively, as demonstrated by the fact that almost three quarters of the opinions are located in places that both models consider to be maximum quality.

The analysis of the two models shows that the psychological model produces more and better positive ratings than the psychophysical model. The spatial correlation between the differences of the two models and the location of the opinions given by the users shows that the differences are clearer in the places judged (and in the context of this study we assume visited) by the users. This pattern can be interpreted as a correlation between the places visited and the places with better ratings: the users tend to give more and better ratings to the places they have visited than to the places they have not. This finding is significant because it relates the attractiveness of the landscape with the precisions by Avila Callau et al. (2019) on perception and accessibility. Respondents' scores are also influenced by personal attachments such as place of birth or visitation experience. Research approaching variability in perceived scenic values (Chien et al., 2021) also points out the difficulty of assessing collective perspectives due to the variation of cultural backgrounds. Probably, this ought to be considered as something inherent to aesthetic assessment studies.

It should not be surprising that the two compared models provide divergent results since, as seen, they are based on different premises and are subject to different conditioning factors. The classification by Daniel and Vining (1983) presents these theoretical frameworks as the most coherent and integrating, but this does not mean that they are synonyms and can, therefore, replace one another. In fact, the opposite is true, as the interesting thing is to use them to complement each other because they are founded on a different rationale, consider different concerns and result in appreciations which, although different, cannot be obtained by using just one single model. Site 2, Sant Antoni salt panes, is a good example. The psychophysical model detects a high-scored combination of landscape features and rates this place positively. However, the psychological model provides a higher score due to the fact that respondents visit the information centre in this site and, because of that, not only are they able to know about it but they are also prone to produce judgments on it.

The main bias for the psychophysical model are land cover types and their distribution, and for the psychological model, the respondent's background and visitation experience. However, both models benefit from other variables or characteristics that make their contribution unique. For example, it is difficult for the psychophysical model to approach sensorial variables such as noise or smell (Subiza-Pérez et al., 2019; Tveit et al., 2018), while the psychological model is unable to objectively systematize variables such as diversity or harmony (Karasov et al., 2020). Both models focus on aesthetic landscape assessment, but from different points of view and using differentiated procedures. It is logical that they produce different results. Dronova (2019) indicates the difficulty of producing this kind of assessments, and suggests that their dependency on social constructions which, by definition, are complex and need to be addressed in a comprehensive and multiscalar manner, is a limitation to be overcome.

The interest in comparing these two models lies not so much in revealing differences, but rather in detecting points in common and in divergence, and in explaining their behavior from the paradigms that generate them and the difficulties limiting them. Daniel and Vining (1983) are right when they highlight the solidity of these approaches, but their excellence must not assume them to replaceable by one another, but rather as a complement to each other, to generate information together which they would not be able to provide separately.

5.2. *Representativeness of the models*

An inevitable question is which of these two models represents reality in a more reliable way, particularly as they provide different results. The response to this question is more complex than it appears, as it depends on the landscape definition one wishes to consider.

As already mentioned, the psychophysical method generates a more objective approximation than the psychological procedure. In fact, not only classifications like the one by Daniel and Vining (1983), but also systematic organizations such as that proposed by Tveit et al. (2018) include the former among objective approaches and the latter among subjective ones. This relative objectivity translates into relative universality and from there the possibility of considering the psychophysical model as a spatial model for the landscape's potential aesthetic quality. In fact, as Martínez Vega, Martín Isabel, and Romero Calcerrada et al. (2003) notice, the particularly distinctive trait is not the objectiveness *per se* of the ratings, but rather the systematic approach with which they are formed, which guarantees a degree of effectiveness when the procedure is repeated. However, this quality of the psychophysical model should not invalidate the psychological one, since, whether or not they can be generalized, both approaches are legitimate. Lothian (1999) summarizes this apparent contradiction with the term "paradox of the landscape", whereby it is not possible for these contrary approaches, i.e. beauty as something intrinsic and inherent in the landscape, or as something extrinsic and attributed by the observer, to both be correct. The explanation of this lies in understanding the landscape aesthetics as a cultural perception, in other words, as a social product which, even though it can be measured and quantified, is still a dynamic reality susceptible to being interpreted from a myriad of slants.

Landscape assessments are not the univocal result of one single element or variable, and instead they are the fruit of a more or less complex list of judgments or opinions, some of which can have a predominant role. In this respect, Antrop (2000) underlines the holistic character of the landscape, whereby everything is more than the sum of its parts. Within this conceptual framework, each element is defined on the basis of other factors, and shapes the appearance of patterns and structures that express the *genius loci*, or the place's own character. This way, the context becomes a key part of aesthetic assessment (Van Zanten et al., 2016) since similar elements can be considered differently according to their location or environment, or even according to the range on the scale where the observer places them. In this respect, we support the work by Tieskens et al. (2018) whereby attraction towards a landscape occurs for different reasons, with the aesthetic element being only one of them. All this leads us to affirm that different variables are involved in the aesthetic assessment of a landscape, and not all of them are a direct reflection of the beauty of the landscape.

6. Conclusion

We have compared two traditional models of aesthetic landscape assessment, in an exercise which, as far as we know, has not been conducted to date. The psychophysical and psychological models have proved to produce different approximations. Although both models tend to coincide in the distribution of the positive ratings, the ones in the psychological model are more numerous, more extensive and have a higher quality than the ones in the psychophysical. This fact is related to the distribution of users' opinions which, in turn, relates to the user's personal background and visitation experience.

It should come as no surprise that the two models are divergent, since it is normal that their conceptual and methodological differences lead to a low correlation rate, both in terms and space. The main contribution from the psychophysical model lies in the universal nature it adopts and the systematic way it is applied, which allows inferring a certain potential aesthetic value. The interesting part of the psychological model, on the other hand, is that it reflects a true assessment, based on aesthetic judgments which, nevertheless, in practice, can be the result of different impressions that in the strict sense are not defined by the beauty of the landscape. The analysis conducted on six selected sites confirms that both models behave differently in a given site, according to varying drivers. Consequently, the interest in both procedures lies not in their ability to substitute one another, but in the way they complement each other, the fact that they provide the same type of information from two different views and that, therefore, they enrich any attempted approximation to the aesthetic values of a certain landscape.

The method conducted hereby is generic and it can be applied in any settings. The robustness of this contribution to landscape theory includes repeating this procedure in other environments with different setups to those analyzed in the Ebro Delta. In the same way, a logical step to follow is to determine which procedures can be useful for synthesizing the contributions from both models in one single procedural framework, and therefore address aesthetic landscape assessment with greater diversity and using a stricter approach.

Declaration of Competing Interest

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

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