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PREDICTING VISUAL AESTHETIC PREFERENCES OF LANDSCAPES NEAR HISTORICAL SITES BY FLUENCY THEORY USING SOCIAL MEDIA DATA AND GIS

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Abstract

There is an interactive relationship between humans and landscapes. Humans inherently assess landscapes by creating spontaneous preferences based on surrounding stimuli. Vision plays a key role in these preferences. Visual preferences are relevant for understanding visual aesthetic liking (VAL), which needs to be evaluated objectively. This study was carried out in Herakleia ad Latmos, comprising Lake Bafa Natural Park and the Latmos-Beşparmak Mountains. The aim of this paper is to predict people's VAL of historical sites (HS) by applying processing fluency theory to social media data. Among fluency theory metrics, four metrics – visual simplicity, visual symmetry, visual contrast, and visual self-similarity, were used to develop an ordinary least squares (OLS) regression model. Two primary questions are explored in this study: (1) How to quantify spontaneous visits of people near historical sites, and (2) how to estimate preferences of people based on distances to HS regardless of landscape types (either cultural or natural). Results show that people mostly visited three HS out of thirteen historical sites between 2004 and 2020: Kapıkırı Island (HS 1), and the ancient cities of Herakleia (HS 2) and Latmos (HS 3). According to the findings of the OLS regression model, year (t = 8.99, p <.0001), visual simplicity (t = -4.64, $p \leq 0.0001$), and visual contrast (t = -2.01, p = 0.04) of the geotagged photos were all statistically significant predictors of VAL. HS 2 had the highest VAL value, followed by HS 1, and HS 3.

Keywords: Visual Aesthetic Liking, GIS, Fluency Theory Metrics, Historical Site, Latmos

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INTRODUCTION

Intriguing features of landscapes have relevant effects on human aesthetic preferences (Maulan et al., 2005; Özdemir and Fenkçi, 2016; Atik et al., 2017; Barromi-Perlman, 2020). People inherently acquire some information with the stimulus they receive from objects in their environment, and they react to their own psychological, physical, and cultural backgrounds by accepting (liking) or rejecting (disliking) the objects, depending on their experience (Kaymaz, 2012). Based on these judgments, people ascribe value to their environment (Bruns et al., 2015). Analysis of VAL can contribute to both cultural and natural landscapes by protecting cultural heritage, while increasing tourism potential and recreational opportunities (Maitland and Smith, 2009; Wang et al., 2016; Motevalian and Yeganeh, 2020). For this reason, assessing VAL is valuable; it is explicitly considered an important resource comparable to soil and water (Kane, 1981; Junker and Buchecker, 2008).

VAL assessment is associated with respondents' perception of landscape attributes, and therefore understanding human perception of the landscape plays a key role in landscape appraisal (Daniel, 2001; Filova et al., 2015; Huang and Lin, 2020). There are many explanatory factors that influence aesthetic preferences. For instance, experimental studies have suggested that people tend to prefer complex landscapes (Kaplan and Kaplan, 1989; Ode et al., 2010; Tenerelli et al., 2017). Ode et al. (2010) highlighted that people prefer intermediate levels of complexity more than low or high complexity (Day, 1967). Similarly, theoretical approaches have shown that environmental patterns of intermediate complexity would be judged as the most beautiful by humans (Berlyne, 1974; Sheppard, 2001; Tveit et al., 2006). Besides complexity or simplicity, there are other factors such as visual self-similarity, visual contrast, and visual symmetry associated with the level of VAL (Graf and Landwehr, 2015; Mayer and Landwehr, 2018).

People judge objects in various ways. One of them is determining their liking, or appreciation, of the things or features they see. Processing fluency theory holds that people prefer, or like better, objects and images that are more easily processed by the visual system (Mayer and Landwehr, 2018). This ease of processing, hence liking, can be assessed by using a stimulus-driven set of empirically accessible metrics: visual simplicity, visual symmetry, self-similarity, and visual contrast. Visual simplicity is a conceptually simple feature of an image or object. Simplicity determines the intensity of the stimulus provided by an object. Those with fewer or simpler features tend to be more easily processed than those with complex characteristics. Fluency theory asserts that simplicity determines the nature of visual processing by people. Visual symmetry is the identity of some features of objects during reflection or translation on a Euclidean plane. Human beings can easily detect symmetry because of the nature of the visual system. Mirror symmetry illustrates the practical application of visual symmetry, because an individual can determine the similarity of an object or a portion thereof when it is mirrored along the central axis. Self-similarity is a property in which an object has the same features whether it is enlarged or diminished in size, i.e. scale invariance. Self-similarity simplifies perceptual processing, increases fluency, and thus should contribute to preferences for visual objects. Visual contrast, the quantitative difference between figure and ground, helps in identifying objects as they are seen. It facilitates easy processing and understanding of a stimulus. Contrast helps human beings identify the things they like from the environment they are in (Figure 1).

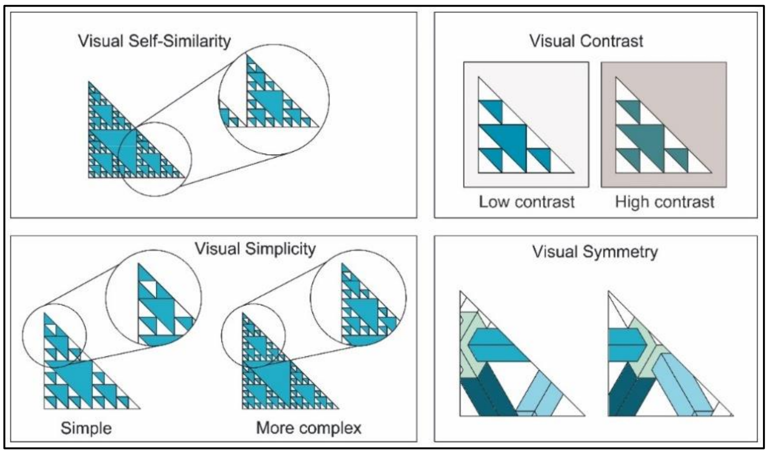

Figure 1: Illustration of the Image Fluency Metrics
(The Illustration Was Generated by the Author in Adobe Photoshop CS5 Software)

In this study, four metrics, introduced by Mayer and Landwehr (2018) within the scope of fluency theory, have been selected as explanatory variables for VAL. The definitions of the Mayer and Landwehr (2018) metrics are summarized above and illustrated in Figure 1.

Aesthetic preferences of landscapes in the visual domain has been investigated mostly by landscape images (photo-based questionnaires), interviews, and field surveys using rank ordering or rating methods (Arriaza et al., 2004; Sevenant and Antrop, 2009; Palmer et al., 2013; Tieskens et al., 2018; Özhancı and Yılmaz, 2019; Arslan and Örücü, 2020a). Recently, there has been an upward trend in the use of geotagged photos from social media platforms for predicting spontaneous visual aesthetic preferences (Tenerelli et al., 2017; Häfner et al., 2018; Langemeyer et al., 2018; Tieskens et al., 2018; Lontai-Szilágyi et al., 2019; Do and Kim, 2020; Gosal and Ziv, 2020). These platforms provide publicly available photos captured by various users with different social and cultural backgrounds that can be used for identifying areas of high popular interest (Arslan and Örücü, 2020b).

This study was carried out in Herakleia ad Latmos comprising Lake Bafa Natural Park and the Latmos-Beşparmak Mountains. The aim of this paper is to predict people's VAL of landscapes near historical sites (HS) by fluency theory, based on social media data. The four fluency theory metrics were used to examine correlates with VAL, and potential prediction, using an ordinary least squares (OLS) model. Two primary questions are explored in this study: (1) How to quantify spontaneous visits of people to HS; and (2) and how to estimate VAL of people at specified distances to HS, regardless of landscape types (either cultural or natural).

Aesthetic preference is a shifting psychological paradigm, thus, it is difficult to make an objective assessment to reveal the level of preference (Lothian, 1999; Mayer and Landwehr, 2018). Therefore, the higher the objectivity of the assessment, the better the VAL of an area could be measured. For this reason, this study is focused on the algorithmic measures for antecedents of aesthetic preferences introduced by Mayer and Landwehr (2018) in the context of the fluency theory.

Geotagged photos, combined with VAL, indicate which HS remain in the foreground or background. In other words, analyzing people's aesthetic preferences spatially can be helpful in describing which historical sites (HS) draw higher attention by people. This study targets researchers and land managers so as to emphasize and promote historical landscapes. This contribution can play a vital role when preparing long term management plans for historical assets.

MATERIAL AND METHOD

The study area is situated on the lower Meander Valley known as ancient Caria within the boundaries of Milas district of Muğla Province and Söke district of Aydin Province covering an area of 55,366.33 ha. The area has a great variety of landscapes representative of various ecological, cultural, geological, recreational, and historical potential assets (Herda et al., 2019).

The ancient city of Herakleia, the Byzantine monastic settlement, Kapıkırı Village, and Bafa Lake Natural Park are located at the foot of the Beşparmak Mountains, known as Latmos in ancient times. Within the ancient city of Herakleia, there are 13 historical cloisters known as unique cultural sites in Latmos, where ancient rock paintings were found dating to the 6th-5th millennia BCE (Peschlow-Bindokat et al., 2012). The fortification of Ikiz Island was built on the edge of Lake Bafa to protect these cloisters during the Byzantine period (Thonemann, 2011). There are five islands in the lake, shaped by rock outcrops: Kahve Asar Island, Ikiz Islands (comprising Küçük Ikiz Island and Büyük Ikiz Island), Menet Island, and Kapıkırı Island. Archaeological remains exist both on the islands in the lake and in Kapıkırı Village (Hetemoğlu, 2019). The geographical location of the study area is represented in Figure 2.

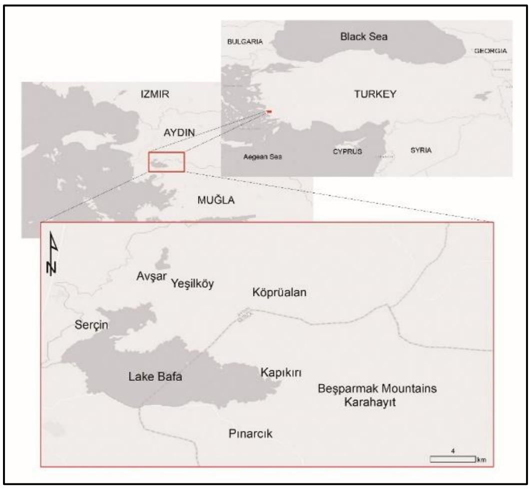

Figure 2: Geographical Location of the Study Area

Once a part of the Gulf of the Aegean Sea (before the classical period), Lake Bafa was isolated from the sea by alluvial sediments from the Meander River, gradually becoming an alluvial dam lake (Müllenhoff et al., 2004). Growth in settlements, agricultural intensification, unsustainable grazing, and timber harvesting have fragmented the landscape around the lake, beginning more than a decade ago (Esbah et al., 2010). A recent case study highlighted that there is an urgent need in the area to prevent the disappearance of archaeological sites, endemic biota, and geomorphological features threatened by increasing mining activities (Gül et al., 2019).

Lake Bafa and its vicinity were officially declared as a nature reserve named Lake Bafa Nature Park in 1994 (DKMP, 2020). The park has great potential for tourism and offers recreational activities such as fishing, bird watching, camping, hand-line fishing, and nature walking (Deniz et al., 2011).

According to the literature review and experts' suggestions, important historical sites, their descriptions and accessibility information were determined. Their description is given in Table 1.

Table 1: Historical Sites in the Study Area, Their Abbreviations, and Descriptions (Ab: Abbreviation)

Historical Site	Ab	Description	Accessibility	Reference
Kapıkırı Island	HS 1	Kapıkırı is a modern Turkish village situated in the southwestern part of the study area. This settlement was built on the Herakleia ancient city.	Accessible by path, road, and fishing boat	Peschlow-Bindokat (2005)
Herakleia ancient city (also known as Herakleia Ad Latmos)	HS 2	Herakleia is a Carian city on the southern part of the Latmos mountain, which in ancient times had a coastline on the Gulf of Latmos and the Aegean Sea. Herakleia was once an important commercial center linking the port with the roads to the inner Caria region. Although the city was built in the early Hellenistic period, some of the original structures have survived. Prominent city walls and towers, the Athena Latmia Temple, and necropolis ruins are among the important remains of the city. Once Herakleia was isolated from the sea, the city was abandoned and subsequently used as a monastic center in the Byzantine Period.	Accessible by trail, road	Stelee (1992) Peschlow-Bindokat (2005) Hülden (2012) Freely (2002) Peschlow and Posamentir (2012)
Latmos ancient city	HS 3	The ancient city of Latmos was to the east of the modern town of Kapıkırı, on the shore of Lake Bafa. It predated Herakleia, with its origin possibly in the 8th century BCE.	Accessible by path, road	McNicoll (1978) Hülden (2000) Peschlow-Bindokat (2005) Peschlow (2014)
Ikiz Islands (Küçük Ikiz Ada and Büyük Ikiz Island)	HS 4	These two islands, in the northeastern part of Lake Bafa, are accessible only by local fishing boat. On Küçük Ikiz Ada, there is an ancient monastery complex. Remnants of Byzantine defensive structures can be seen on Büyük Ikiz Ada.	Accessible by fishing boat	Hetemoğlu (2019)
Menet Island	HS 5	A fortified island, known as Menet Ada, in northern Lake Bafa includes ancient ruins. Accessible only by fishing boat.	Accessible by fishing boat	Wiegand (1913) Hetemoğlu (2019)
Kahve Asar Island	HS 6	There is a fairly well-preserved monastery on this island, which is close enough to shore to be reached on foot when the lake level is low.	Accessible by fishing boat	Hetemoğlu (2019)
Mersinet Pier	HS 7	Mersinet Pier, located on the southern shore of Lake Bafa, appears to have been a medieval monastery.	Accessible by path, fishing boat	
Yediler Monastery	HS 8	This monastery complex is on the Latmos mountainside, accessible by rocky footpaths.	Accessible by path	
Süzbük	HS 9	Süzbük is the site of a small church with a watchtower.	Accessible by path, boat	
Burgaz Island I	HS 10, HS11, HS12	The island consists of three parts, each a necropolis from the ancient cities of Herakleia and Latmos.	Accessible by road, path, boat	
Sobran Castle	HS 13	The Sobran castle, north of Süzbük, includes a chapel and a watchtower.	Accessible by path, boat	

Methodology

The methodology of this study consisted of five steps: (1) data collection and preparation, (2) computation of image fluency metrics, (3) developing an OLS model, (4) spatial analyses incorporating proximity and overlay analysis, and (5) assessment of VAL of the geotagged photos based on specified distances to historical sites.

Platforms such as Flickr and Google Earth (previously Panaramio) have been widely used and have contributed to VAL-based studies (Tenerelli et al., 2017). In this study, all geotagged photos that had been taken between 2004 and 2020 and shared on Flickr and Google Earth were collected. Only landscape-related photographs were used and non-related photographs such as selfies or photographs that focused on people were deleted. Flickr API was accessed via the *photosearcher* library of the publicly available R software (Fox, 2020). This library enables users to download geotagged photos and specific attributes such as title, time taken, latitude, longitude, count view, hashtags, user identity, etc. Among them, *times*, showing upload time, and *count view*, indicating the total number of views of the photographs by other users were extracted as a .csv file. Photos from Flickr were saved in .jpg format. Since latitude and longitude information of the photos were recorded as a .csv file from R, the point shapefile was created in ArcMap 10.7. For the data collection from Google Earth, landscape-related photos were downloaded by manual compilation and saved as .jpg format. Furthermore, each place mark of the photos was recorded as .kmz files. Next, all .kmz files were converted into the point shapefile dataset by the *Geoalgorithms* tool of QGIS 2.8.8. Then, the point shapefiles of Flickr and Google Earth geotagged photos were combined in ArcMap 10.7. For determining the geolocation of historical sites in the study area, a literature review was done. Additionally, when generating a historical site map, archaeological experts were consulted.

For calculating fluency metrics of each photo, an executable script was written in R using the *imagefluency* library and the metric values were assigned to each photo. The results were saved as a .csv file to be utilized in ArcMap 10.7 for the further steps of the spatial analysis.

The number of views (count view), an indicator of aesthetic preference, was used as the response variable for developing an ordinary least squares (OLS) regression model in R statistical software. Count view information was only available from Flickr. Therefore, only Flickr-derived photos were utilized in the model. To reduce skewness in the count view, the variable was $\log_e$ transformed. The model suggested by Mayer and Landwehr (2018) included the four image properties as predictors. In the model as applied here, the variable TIME (year photo was uploaded) was added as a nuisance variable (i.e. one that has no theoretical value, but is a source of significant variation in the response variable).

$$\log(\text{VIEWS})_i = b_1 \times \text{TIME}_i + b_2 \times \text{SIMPLICITY}_i + b_3 \times \text{SYMMETRY}_i +$$
$$b_4 \times \text{CONTRAST}_i + b_5 \times \text{SELF-SIMILARITY} + \varepsilon_i.$$

Once the estimates of statistically significant predictors were computed, a new column was created in the attribute field of the point shapefile data and VAL of each geotagged photo was estimated in ArcMap 10.7. The VAL values were ranked into three groups as low, medium, and high using quantiles (percentiles). High, medium, and low VAL values were regarded as high, medium, and low fluency.

Spatial analyses conducted in this study included proximity and overlay analysis. To analyze the distribution of geotagged photos, a kernel density map was generated. According to specified distances, proximity analysis was employed in ArcMap 10.7. An overlay analysis was done to quantify the number of visits in each buffer zone and associate distances from historical sites with VAL.

RESULTS AND DISCUSSION

Thirteen important HS are shown on the map in Figure 3a. The kernel density map in Figure 3b indicates that geotagged photos were not normally distributed in the area, and mainly focused on Kapıkırı and its environs. A total of 6091 photos taken from the study area between 2004 and 2020 were analyzed. From these, 651 landscape-related photos taken by 106 different users qualified to be used in this study.

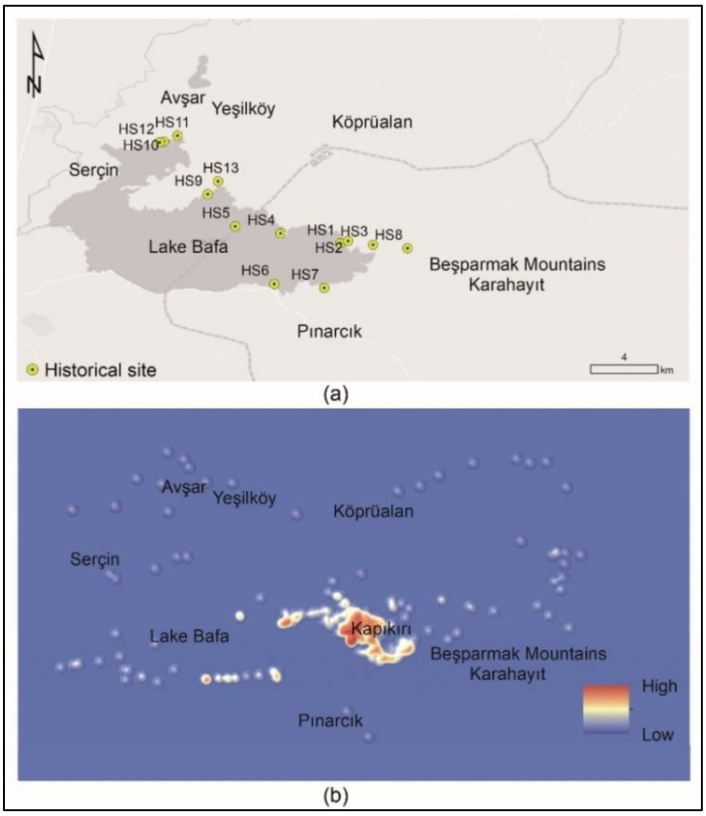

Figure 3: a) Historical Sites (HS) in the Study Area, (**b**) Kernel Density Map

Four maps were obtained by creating buffers around the historical sites (Figure 4). Buffer distances were determined as 250 m, 500 m, 750 m, and 1000 m. It can be seen visually that more geotagged photos are contained within the larger buffer areas.

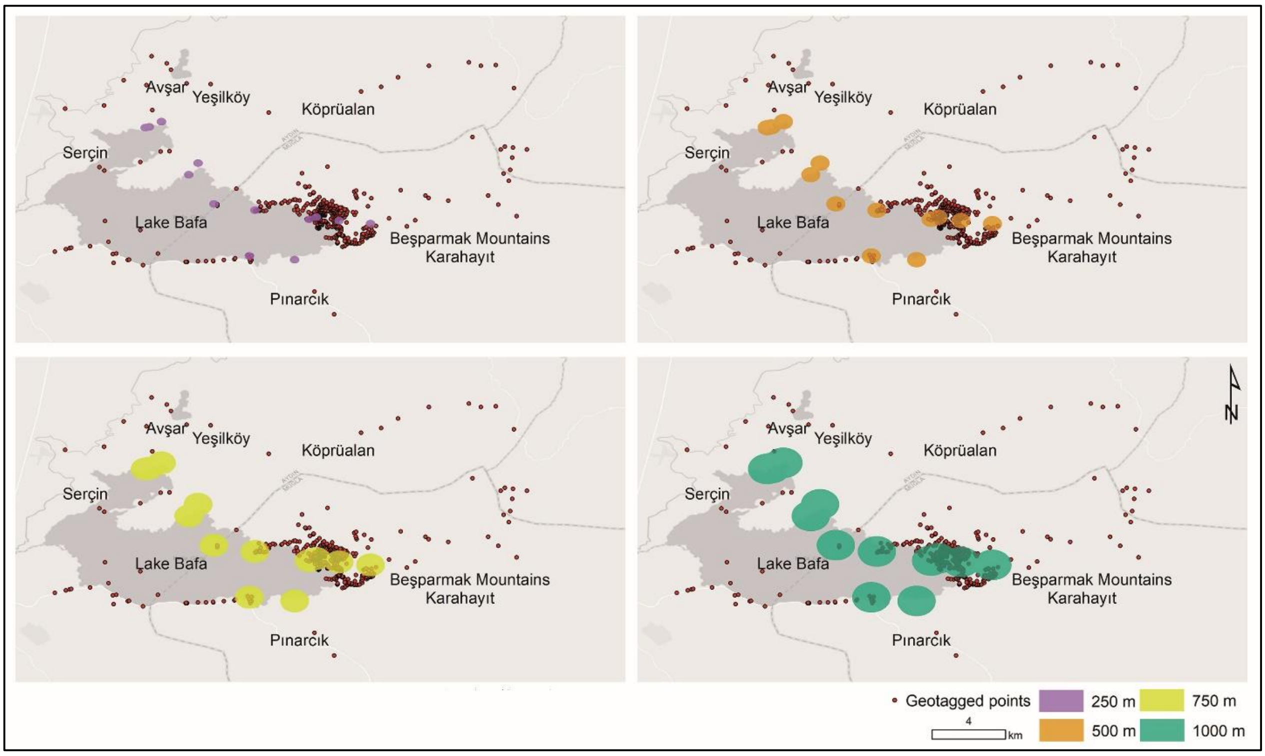

Figure 4: Proximity Analysis with Buffers (Distance in Meters)

The results of the OLS regression model, including parameter estimates and associated p-values for all variables are presented in Table 2.

Table 2: Parameter Estimates of the Model

Term	Estimates	Std. Error	t value	Pr(>|t|)	VIF
(Intercept)	3.13351	0.20880	15.007	< 2e-16	.
Contrast	-0.21744	0.10818	-2.010	0.0454	1.253171
Self-similarity	-0.12665	0.10542	-1.201	0.2306	1.190055
Simplicity	-0.58889	0.12692	-4.640	5.37e-06	1.724806
Symmetry	0.15860	0.12920	1.228	0.2207	1.787404
Time	0.29424	0.03273	8.991	< 2e-16	1.024363

The results showed that date uploaded (time) (t = 8.99, p <.0001), simplicity (t = -4.64, $p \leq$ 0.0001), and contrast (t = -2.01, p = 0.04) were all statistically significant predictors of the logged geotagged counts. The slope estimates for contrast and simplicity were -0.217 and -0.589, respectively, indicating that for every unit increase in contrast the response drops by -0.217 units on the natural logarithm scale or exp(-0.217) = 0.80 units for contrast and 0.55 units for simplicity. Since all VIF scores were less than 2, there is no evidence of multicollinearity between the predictors. A plot of residuals versus predicted values is shown in Figure 5. The residual plot shows that the residuals are randomly scattered about zero with constant variance with no apparent outliers. The model fits the data adequately.

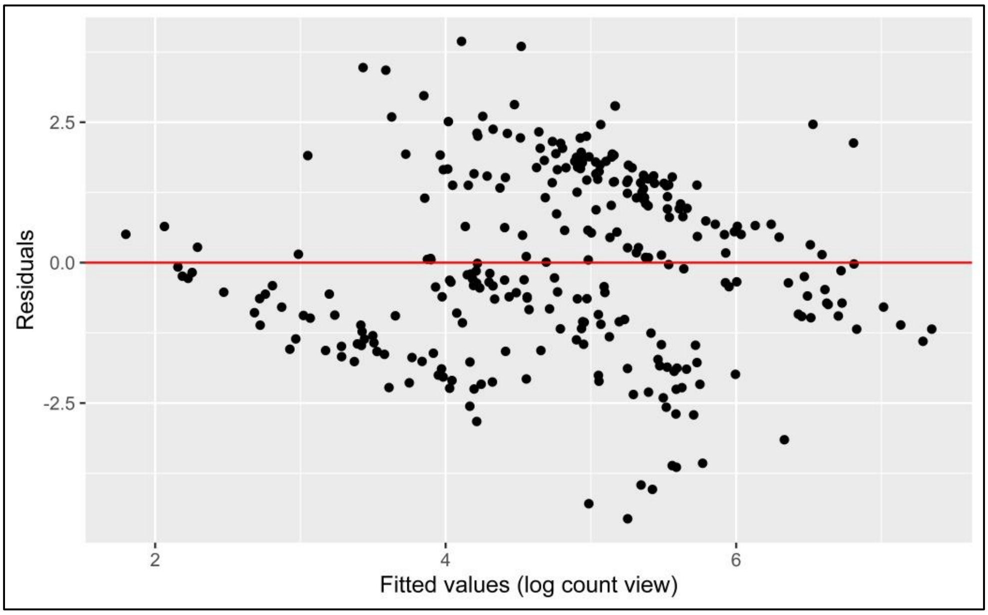

Figure 5: Residual by Predicted Plot

Figure 6 shows the results of comparing VAL values contained within various buffer distances around the HS. Figure 6a indicates, as expected, that the greatest number of photos among four distances was at 1000 m, followed by 500 m, 750 m, and 250 m, except for HS 5. Interestingly, the number of geotagged photos was equal for HS 5 at all buffer distances. HS 2 had the highest number of geotagged photos in four buffer distances, followed by HS 1, and HS 3. On the other hand, HS 4, HS 8, HS 6 and HS 5 did not have important numbers of photos when compared to HS 1, HS 2, and HS 3. In fact, 250 m is an important distance because it implies accessibility to a particular HS. There is a slight difference in the number of geotagged photos for HS 3 and HS 4 at the 250 m distance.

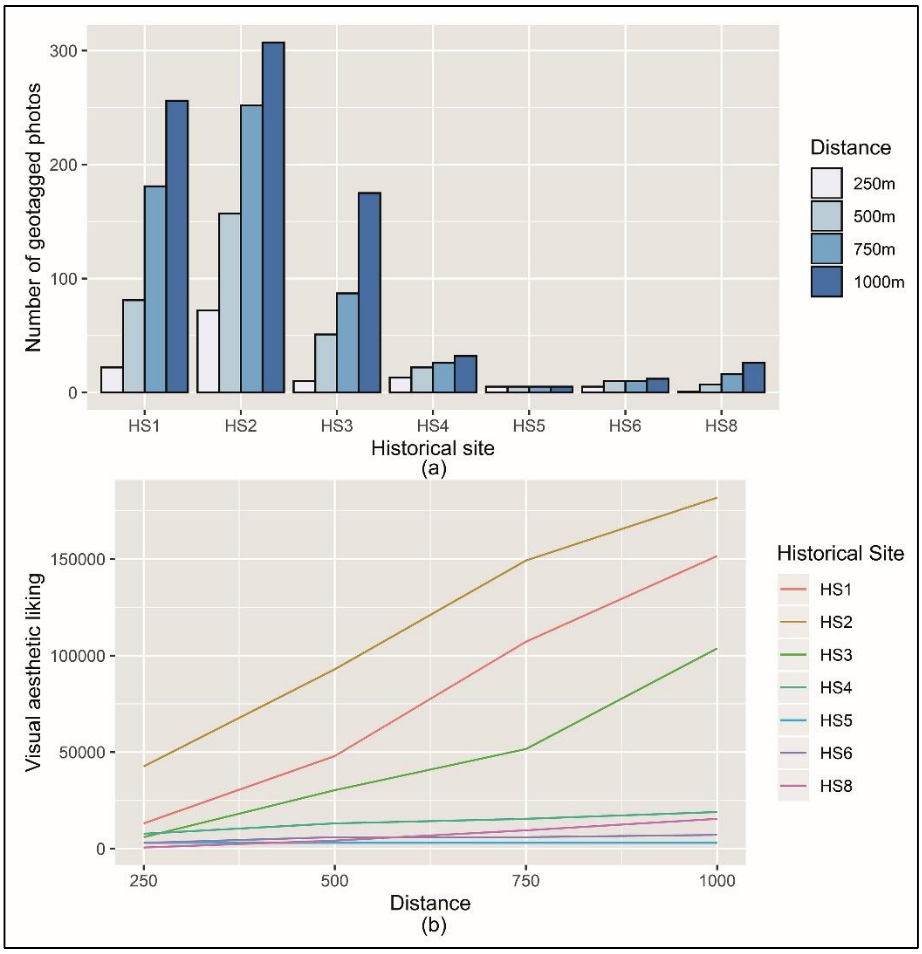

Figure 6: a) The number of Geotagged Photographs Taken at Historical Sites by Four Buffer Distances,
(b) Total VAL Values by Four Buffer Distances

The number of photos clearly is associated with VAL. Furthermore, VAL preferences change according to different buffer distances. Figure 6b shows that HS 2 had the highest VAL value, followed by HS 1, and HS 3. HS 5 and HS 6 had the lowest VAL values at four buffer distances. HS 4 and HS 8 were relatively higher than HS 5 and HS 6. VAL levels of some randomly chosen geotagged photos are shown in Figure 7.

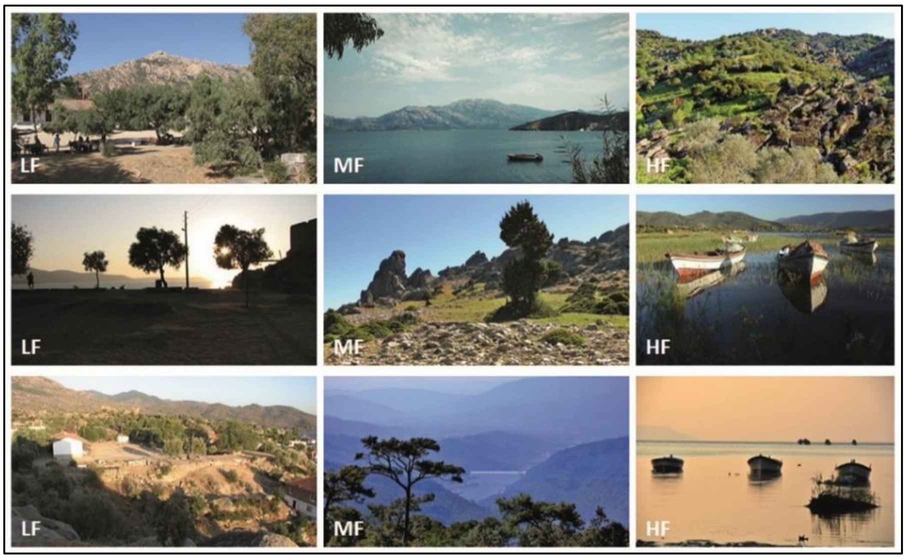

Figure 7: Visual Aesthetic Liking Levels of Some Randomly Chosen Geotagged Photos
(LF: Low Level of Fluency, MF: Medium Level of Fluency, HF: High Level of Fluency)

Comparing the statistical results of the OLS model with those of Mayer and Landwehr (2018), both studies found that simplicity was a significant indicator among fluency metrics. On the other hand, while they found that self-similarity was another important indicator, visual contrast was a more important independent variable in the present study. Although the time variable was significant, the only inference is that more photos were available from more recent years; there is no relation to fluency. The difference may have to do with the response values used in the model. They used "rank" as a variable in the model which means simply the position on the website when searching for a term like "landscape". The idea was that images that are shown first within the list of search results have a higher likelihood of being perceived and hence a higher likelihood of receiving likes. They intended to control for the position on the website in their analyses. In the model presented in this paper, rank was not used due to the fact that ranks were not available from either Google Earth or Flickr. Because of the updated privacy policy of social media platforms, the rank information is inaccessible today.

The difference in the findings could be caused by the limited number of geotagged photos for developing an OLS regression model. A total of 284 geotagged photos were available from Flickr in the study area and only these photos were used in the OLS model since they had count view and time information. If the number of observations were higher, the results could be different. Although 284 geotagged photos are enough to develop a statistical model, greater numbers of observations can give clearer results. The privacy policies of social media platforms also affected the number of observations. It is not possible to download photos automatically from many popular platforms today.

This study did not aim to ask people this question: "How much do you like this landscape visually?". This study can, however, be compared with traditional methods for predicting VAL such as interviews or surveys. The experimental data should be generated so that the correlation between the VAL model and experimental results can be tested to inform the validity of fluency theory.

Buffer distances used in this study reflect the probability of visits to historical sites. However, this study did not aim to understand people's VAL of historical sites directly. It was intended to focus on the environs of historical sites, regardless of whether the site features historical material, is dominated by vegetation, or focused on the lake.

The buffer distances were determined by a trial and error method. For instance, at less than 200 m, there were almost no photos directly of the environs of the historical sites. Since VA preferences change according to the distance, more than one buffer was used in this study. One km seems a long way, yet there is still a probability that people will visit an HS at this distance.

There can be other factors that affect people's VA preferences. For instance, visual scale was used in some previous studies (Tveit, 2009; Laroche et al., 2020). All factors that have possible impacts on VAL can be used in an estimation model and the success of the model can be tested with traditional methods.

The literature for determining HS and their accessibilities show that most of the HS were inaccessible by trails and roads. This difficulty may affect the number of photos. Hetemoğlu (2019) recommended that access could be improved by organizing regular boat tours to transport tourists from the village to the islands (Kapıkırı Ada, İkiz Ada, Menet Ada, Kahve Asar Ada) and Mersinet Pier If this recommendation were put into effect by land managers and organizers, it would be possible to predict VAL more realistically.

Previous studies have shown that if a landscape is surrounded by a water feature, such as sea or lake, people have a tendency to visit these areas often. This effect can explain the findings of higher numbers of photo around Herakleia ancient city.

When people perceive the landscape and assign a value to it, they use a high-level visual evaluation mechanism and tend to prefer landscapes that visually valuable. There can be two reasons why a landscape is not preferred by humans:

- The area is not accessible due to its topographic structure or the slope difference is high and it is not preferred except for people who are interested in specific recreational activities such as nature climbing and hiking.
- The site is not adequately promoted. Landscapes may have some restrictions or are not widely known. Therefore, they are not preferred by people.

As mentioned in the materials and methods section in this paper, the study area faces several pressures today. Due to the rising activities of mining and agricultural intensification, the landscape has been fragmented over time. There will be a need for landscape restoration in the study area. To do a restoration and prepare a long-term management plan, people's VAL can be used as criteria. If the VAL features are revealed in the area, the degraded sites can be designed with these features. People tend to preserve the landscape features that they prefer visually. When determining the protection goals of the landscape, it is important not only to consider their natural, cultural, or historical values, but also visual values derived from people's VA preferences. Identifying the visual value given to the landscape by people, especially in landscapes that are under pressure, helps to promote the areas with their potential and to develop new protection strategies. For this reason, determining VAL plays an important role in both planning and design of the landscape.

CONCLUSION

As one of the cultural ecosystem services, landscape aesthetics play a key role in human health and social benefits. Adding visual preferences of humans into land-planning decisions help to make more effective plans. Visual preferences are relevant for understanding VAL and VAL needs to be evaluated by avoiding subjectivity. This study showed that how landscapes near historical sites can be assessed in terms of VA preferences using social media data. VAL was quantified, demonstrating that three HS had a higher VAL from people. The frequency of people's visits to these areas was higher than other historical sites.

Aesthetic judgment is a complicated phenomenon to measure. Measurable characteristics of the fluency framework are relatively new. The fluency concept can be supported with experimental data and new algorithms can be developed to predict people's VAL in different types of landscapes.

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Appendix 1: Leverage Plots of the OLS Model