Visual and Environmental Quality Perception and Preference in the People's Republic of China, France, and Portugal

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Abstract—Planners, designers, environmental specialists, governmental agencies, non-profit environmental organizations, and citizens are interested in scientifically based tools to assist in the study of the landscape. In this investigation, we present a science based visual and environmental quality predictive model useful in understanding and assessing landscape treatments of the contemporary Chinese, French, and Portuguese populations. We developed respondent based equations of visual and environmental quality preference that explain between 20 and 40 percent of respondent preference, with an overall p-value for the equation ≤ 0.0001 and a p-value < 0.05 for each regressor. Regressors employed in the equation include an environmental quality index, foreground vegetation, area of vehicles, area of water, and area of humans in an image. The French and Portuguese have similar perceptions but in many respects the Chinese response is quite different than equations that explain Western landscape preference where the equations can predict much more of the variance. The study suggests that Chinese landscape perception may be quite different than Western perception. In addition, more thought may be required to develop predictors of both Chinese and European preference.

I. INTRODUCTION

Investigators have been attempting to explain and predict the preference of respondents concerning landscape structure, contents, and composition for the last 50 years [1]. Taylor, Zube and Sell presented an overview of the various approaches to predict visual quality; and Smardon, Palmer, and Felleman present the fundamentals of visual quality research [2, 3]. Lee and Burley discuss recent methods and authorities since Taylor's, Zube's, and Sell's 1987 paper [4]. Lee and Burley also illustrate how one can compare and

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measure visual quality between photographic sets and pairs. Such approaches were also presented by Burley in 2006 and Lu (et al.) in 2010 for surface mine planning and design applications [5, 6]. In contrast Burley illustrated applications in billboard studies for an agricultural setting [7]. In addition Mazure and Burley discussed the relationship between artistic landscape drawings and the science of landscape visual quality [8]. While, Noffke and Burley present attempts to map visual quality based upon these equations [9]. Much of this work and similar efforts are focused upon North American respondents. For Burley's and colleagues' efforts, the seminal modeling effort was published in 1997, where they presented a highly detailed equation predicting respondent preferences [10]. Predictors in these models include an environmental quality index, man-made features and many natural landscape features (Table 1). The regressors form a predictive equation (Equation1).

Table 1. Variables in an equation reported by Burley [10].

HEALTH= environmental quality index (Table 2)
X1= perimeter of immediate vegetation
X2= perimeter of intermediate non-vegetation
X3= perimeter of distant vegetation
X4= area of intermediate vegetation
X6= area of distant non-vegetation
X7= area of pavement
X8= area of building
X9= area of vehicle
X10= area of humans
X13= area of herbaceous foreground material
X14= area of wildflowers in foreground
X15= area of utilities
X16= area of boats
X17= area of dead foreground vegetation
X19= area of wildlife
X30= open landscapes = X2 +X4 + (2*(X3+X6))
X31= closed landscapes = X2 +X4 + (2*(X1+X17))
X32= openness = X30-X31
X34= mystery = X30*X1*X7/1140
X52= noosphericness = X7+X8+X9+X15+ X16

The equation (model) includes theories to explain the equation(s). Mazure and Burley describe their theories [8]. They note that originally, Dr. Burley and Amy Mazure believed that the equation could be explained with a general

theory. They call the underlying theory, "Biospheric Preference Theory." In this theory, they postulate that the respondents have a preference for biospheric surroundings, meaning plants, wildlife, flowers, distant views to landforms, clean air, clean water, and related features. Conversely, the respondents have a dislike for noospheric (urban/man-made) surroundings.

In many respects, they would like to believe, this theory makes sense. For example, consider either an urban or rural setting in North America. Which residential properties have increased the most in value? Ideally, these properties contain a commanding distant view, are next to trees, contain some wildlife like songbirds, have a low density of nearby houses, contain quiet streets with few automobiles, have relatively few people, and have fresh air and clean water. Therefore, the results derived from equation 1 and others like it are not surprising and may corroborate some basic values associated with the normative visual/environmental quality preferences of many North American residents.

Table 2. Environmental Quality Index

Variable	Score
A. Purifies Air	+1 0 -1
B. Purifies Water	+1 0 -1
C. Builds Soil Resources	+1 0 -1
D. Promotes Human Cultural Diversity	+1 0 -1
E. Preserves Natural Resources	+1 0 -1
F. Limits Use of Fossil Fuels	+1 0 -1
G. Minimizes Radioactive Contamination	+1 0 -1
H. Promotes Biological Diversity	+1 0 -1
I. Provides Food	+1 0 -1
J. Ameliorates Wind	+1 0 -1
K. Prevents Soil Erosion	+1 0 -1
L. Provides Shade	+1 0 -1
M. Presents Pleasant Smells	+1 0 -1
N. Presents Pleasant Sounds	+1 0 -1
O. Does Not Contribute to Global Warming	+1 0 -1
P. Contributes to the World Economy	+1 0 -1
Q. Accommodates Recycling	+1 0 -1
R. Accommodates Multiple Use	+1 0 -1
S. Accommodates Low Maintenance	+1 0 -1
T. Visually Pleasing	+1 0 -1
Total Score	_____

They have also divided the Biospheric Preference Theory into three sub-theories. The first sub-theory is the "Theory of Human Intrusion." Humans intruding upon one another are not well received by the humans being intruded upon. For example, their work indicates that buildings (up close and personal), no matter how highly acclaimed, are intrusions from one person onto another. In addition, an abundance of people, cars, pavement, eroding soil, and related features are signs of people intruding upon others. Landscapes which dominate with these features are not rated highly.

The second sub-theory is the "Theory of Landscape Enhancements." This theory suggests that people prefer those events from nature that are special and temporal (not easily seen), such as an animal in a scene or flowers on display. Animals move, and flowers have a limited time for blooming. So when these features are present, they are appreciated and enhance the quality of the landscape. In addition, mountains, buttes, and buildings when viewed from a distance are also temporal landscape enhancements which can often be viewed only from specific locations or in specific directions, and appear to behave as variables in a similar manner to other temporal landscape enhancements.

$$
\begin{aligned}
Y = {}& 68.30 - (1.878 * HEALTH) \quad\quad (1) \\
& - (0.131 * X_1) \\
& - (0.064 * X_6) \\
& + (0.020 * X_9) \\
& + (0.036 * X_{10}) \\
& + (0.129 * X_{15}) \\
& - (0.129 * X_{19}) \\
& - (0.006 * X_{32}) \\
& + (0.00003 * X_{34}) \\
& + (0.032 * X_{52}) \\
& + (0.0008 * X_1 * X_1) \\
& + (0.00006 * X_6 * X_6) \\
& - (0.0003 * X_{15} * X_{15}) \\
& + (0.0002 * X_{19} * X_{19}) \\
& - (0.0009 * X_2 * X_{14}) \\
& - (0.00003 * X_{52} * X_{52}) \\
& - (0.0000001 * X_{52} * X_{34})
\end{aligned}
$$

The third sub-theory is the "Theory of Neutral Modifiers." This theory suggests that the common spatial elements (pre-civilization features) found in the natural and even rural landscape such as sky, clouds, green vegetation, and water comprise the neutral environment from which a landscape can be enhanced or de-valued. Landscapes that contain an abundance of neutral modifiers result in visual quality scores that are neither high or low. They are significantly different from those landscapes with an abundance of intrusions and landscapes with an abundance of enhancements.

Mazure and Burley note that the predictors associated with their best model are comprised of aesthetic features, economic features, cultural values, landscape functions, and ecological aspects. In other words, the equation was a combination of a unified perception concerning the environment [8]. Aesthetics, ecology, function, economics, and culture are not separate issues in the view of the respondents. When the landscape is observed and evaluated, the respondents utilize all of these values in the evaluation of landscape.

The combined success of developing equations to predict visual quality and the accompanying theories based upon the perceptions of North American respondents led to the speculation concerning predictive possibilities of other respondent groups. Yu Kongjian studied American and Chinese respondents. He determined that a group of American designers as respondents and educated Chinese had a co-varying response to landscape images [11]. In addition rural Chinese preferences did not co-vary with urban Chinese preferences. We throught this work was promising.

Therefore, we were interested in testing and building a predictive equation based upon Chinese preferences.

Our initial results produced an equation, presented in Table 3, to predict Chinese preference for landscape settings [13]. The variable combination does not exceed C-plot requirements, but only explains a meager 16.53% of the variance. The results suggest a definitive prediction with p<0.0001. But the equation is not able to predict much of the respondents' preference. All of the variables in the combination, including the intercept, are significant. Variable V9 is the area of vehicles in the image. 20 squares of vehicles must be in the image before the equation will be affected by one point.

Table 3. Results from Stepwise MaxR procedure.

R-Square = 0.1653
Pr > F for the overall equation is <.0001

Variable	Parameter Estimate	Pr > F
Intercept	49.69102	<.0001
V9	0.02038	0.0099
SV1	0.00035058	0.0023
CVQ	-0.54637	<.0001
PRC	-9.57137	0.0417

The square of V1 (the perimeter of foreground vegetation) is also a significant variable; however the perimeter has to be quite large to affect the image by one point. In contrast, CVQ, the environmental health variable, is a significant variable, where just a two point change in the index score affect the visual quality by one point. Finally, if the image is from China, the Chinese respondents will rate the image as being preferred by 9.57 points.

In our current study, we were interested in improving the amount of variance explained in the modeling process, and compare the correlations between Chinese respondents and North American respondents. In addition, we were also interested in the responses from French and Portuguese respondents.

II. METHODOLOGY

We followed the procedures and methodology described by Burley (10) where respondents are shown 10 pictures at a time and asked to sort them from most preferred to least preferred. For each respondent this is repeated 5 times (50 pictures total) [10]. Then a new respondent is shown a set of pictures. Once all the pictures have been shown, the images are sorted into a new order, so that each picture has an opportunity to be compared to another picture. The respondents were individuals at Tongji University, in Shanghai, Agro-Campus Ouest, in Angers, France, and the Universidade do Algerve, Faro, Portugal.

The images were a combination of pictures from the original study by Burley with the addition of pictures from China of landscapes. Besides the variables studied by Burley, this study included country of origin as a possible regressor. It was felt that the Chinese respondents might have a difference in preference based upon origin of the image. We base this premise upon that idea of ownership, where a setting, human intrusion, or artifact may be tolerated and even preferred if the respondent is an owner, or has some affiliation with the items illustrated in the image. Following the method of Burley (1997), low values mean high visual quality preference [1]. High values mean low preference.

In addition, we generated and compared the correlations of Chinese, French, and Portuguese respondents to the responses to the same images by North American respondents.

III. RESULTS

Table 4 presents the results of an improved combination of best variables to predict Chinese preference for landscape settings. The variable combination explains a slightly improved 20.69% of the variance. The results still suggest a definitive prediction with p<0.0001. The equation predicts some more of the respondents' preference, by about 4%. All of the variables in the combination, including the intercept, are significant. Variable V9 is the area of vehicles in the image. 20 squares of vehicles must be in the image before the equation will be affected by one point.

Table 4. Results from Stepwise MaxR procedure for Chinese respondents.

R-Square = 0.2069
Pr > F for the overall equation is <.0001

Variable	Parameter Estimate	Pr > F
Intercept	49.47512	<.0001
V9	0.02111	0.0067
SV1	0.00030292	0.0066
SV13	0.00001511	0.0246
SV15	0.00012243	0.0200
CVQ	-0.52224	<.0001
PRC	-10.96449	0.0122
V214	-0.00041626	0.0340

The square of V1 (the perimeter of foreground vegetation) remains a significant variable; however the perimeter still has to be quite large to affect the image by one point. CVQ, the environmental health variable, is a significant variable, where just a two point change in the index score affect the visual quality by one point. The square of foreground herbaceous vegetation is a significant variable, but must become quite large to affect the visual quality score. Also the square of utility structures affects the visual quality score. A substantial portion of utility structures must be in the image before the score will move by one point. As with the original Chinese equation (Table 3) the Chinese respondents will rate the image as being preferred if the image is of a Chinese location.

However the equation now suggests that the image will be 10.96 points better. Finally, the equation suggests that the perimeter of intermediate non-vegetation multiplied by the areas of foreground flowers influences Chinese respondents, improving the visual quality. This was a significant variable in the original equation reported by Burley [10].

Table 5 presents the correlations of the Chinese respondents to three groups of North American respondents. The Chinese respondents correlate less strongly with the North American respondents than the three North American Respondents correlate to each other.

Table 5. Correlations of the Chinese respondents with the three North American respondents.

	N.A1	N.A.2	N.A.3
China	0.40734	0.3741	0.3551
N.A.1		0.70574	0.69103
N.A.2			0.70971

Table 6 presents the results from the French respondents. As in the American respondents and the Chinese respondents, French respondent preferences can be explained in part with the environmental quality index. Images with water and views to distant mountains, buttes and hills also predict favorable French responses. Landscape containing excessive urban features and an excessive amount of people in the image will result in a less favorable perception of the image by French respondents.

Table 6. Results from Stepwise MaxR procedure for French respondents.

R-Square = 0.4142
Pr > F for the overall equation is <.0001

Variable	Parameter Estimate	Pr > F
Intercept	16.78429	<.0001
V5	-0.00122	0.0095
V6	-0.01135	<0.0001
V10	0.01031	0.0105
CVQ	-0.52224	<.0001
V52	0.00463	0.0003

Table 7 illustrates the results from the Portuguese respondents. The environmental quality index was again a strong predictor of image preference. Like the French, the area of humans in the image was a predictor of Portuguese preference, meaning that the more the area of the image comprising humans, the less the image is preferred. Portuguese respondents also had an a preference for less vehicles in the image. Like the Chinese, the Portuguese preferred the image to be composed with the absence of utility structures. The variable area of intermediate ground non-vegetation squared predicted Portuguese preference. As the

square increases, the Portuguese preferred the image less. Finally, the Portuguese preferred images that were less open.

Table 8 presents the results of the correlations between the French respondents and three North American respondent groups. The French respondents correlated relatively similarly between the three North American respondent groups. The correlation between the French and Portuguese respondents was 0.56096.

Table 9 illustrates the results of the correlations between the Portuguese and the three North American respondent groups. The variance of the correlations between the Portuguese and the three North American respondents was greater than between the French and three North American respondents groups, but still relatively similar.

Table 7. Results from Stepwise MaxR procedure for Portuguese respondents.

R-Square = 0.4191
Pr > F for the overall equation is <.0001

Variable	Parameter Estimate	Pr > F
Intercept	16.17770	<.0001
V9	-0.00506	0.0497
V10	-0.01069	0.0041
V15	0.02311	0.0029
SV2	0.00011511	<0.0045
CVQ	-0.35245	<.0001
V32	0.00312	0.0002

Table 8. Correlations of the French respondents with the three North American respondents.

	N.A1	N.A.2	N.A.3
French	0.61838	0.62723	0.61232

Table 9. Correlations of the Portuguese respondents with the three North American respondents.

	N.A1	N.A.2	N.A.3
Portuguese	0.60014	0.5292	0.62241

Table 10 presents the correlations between the Chinese and European respondents. Like the correlations between the Chinese and the three North American respondent groups, the correlations between the Chinese and European respondents were lower than the correlations between the Europeans and the North American respondents.

Table 10. Correlations of the Chinese respondents with the European respondents

	French	Portuguese

China	0.23379	0.36226

IV. DISCUSSION

The variables that were employed in this study were developed based upon Western perception and experimenting with the variables. It seems clear that Chinese respondents may be considering something else when they view landscapes. For example, an image that scored in the neutral range for Westerners (Figure 1) scored very unfavorably for Chinese respondents. The image is of a spruce or balsam fir trunk in Northern Minnesota covered in lichens.

Another image from the Mount St. Helens incident in the State of Washington also scored very poorly (Figure 2). This image depicts a traumatized landscape and a mangled car. For Westerners, this image scores very poorly too. This means that for some images Chinese respondents and Westerners have a similar impression of a photograph. This is revealed by the Environmental Quality Index as being a significant regressor for both respondents.

Figure 1. This image scored very poorly by Chinese respondents (an image from northern Minnesota). (Copyright 1980 © Jon Bryan Burley, all rights reserved, used by permission).

Figure 3 presents an image that was rated very highly by Chinese respondents. The image is of Xi Hu (West Lake) in Hangzhou, Zhejiang Province, People's Republic of China. The image depicts the stone buoys in the lake that "light-up" and present an image of the moon being reflected on the lake. In the background is the recently reconstructed Leifeng Pagoda. Xi Hu is a very scenic spot in China, and reputed to be the home of Marco Polo. The landscape image of the buoys has been featured on Chinese money. During holiday seasons, thousand of Chinese walk around the lake enjoying the scenery. The moon has romantic symbolism. The image also scores quite favorably with Western respondents, although for Westerns, images with wildflowers and wildlife will score even better. The Xi Hu image also has a foggy background affiliated with Chinese mystery and a purposeful lack of clarity. This lack of clarity is often considered intellectual and is reflected in both Chinese paintings and poetry.

Figure 2. This photograph scored poorly for both Westerners and Chinese respondents (courtesy of the United States Forest Service).

Figure 3. This is am image of Xi Hu (West Lake) that was highly rated by Chinese respondents. (Copyright 2007 © Jon Bryan Burley, all rights reserved, used by permission).

There may be many variables that may have generated this disparity in the results, such as individual understanding of visual quality, hobbies, knowledge background, experiences, living environment, social roles, classes, economic incomes, and so forth. But due to the mutual social and culture influences, some factors might affect the general perspective of Chinese people's visual quality preference, which is different from the Western perspective.

Chinese visual quality preference is mainly related to the thousands of years of inherited traditional philosophy of the idealize landscape, with emphasis on creating poetic and artistic prospects or images of the space and living harmoniously with pleasant natural environment [12]. It contains a unique aesthetic attitude of implicit, indistinct beauty of landscape. In this case, the pictures which exhibit this cultural factor might be highly rated, for instance, the image of the west lake. Even though this place has already existed for hundreds of years, it still attracts many people as it exhibits the traditional understanding of an ideal poetic landscape.

Moreover, a "modest-like" philosophy also undertakes an important role in Chinese visual quality assessment. People view an image representing modesty as a perfect status of life and view the blank space as a necessary composition of beauty as well. Thus, if the image contains too much information, lack of the blank and the emphasis on key factors, it might score lower than one with harmonious balance. For example, the picture of the tree from northern Minnesota scored very poorly mainly because the frame is stuffed with pictorial information.

In addition, the dream of a modern life has tremendous effects. With rapid modernization, people obtained the benefit of an ever wealthier lifestyle, which might affect their core values in visual preference. The images containing depictions of modern, wealth related factors might score better with Chinese respondents. The pursuit of a more modernized country is the steering attitude of developments in China nowadays, which could not be ignored when analyzing Chinese visual quality preferences.

Figure 4. An image the scored very well by French respondents. This image also scored very well with North American respondents (courtesy of the United States National Park Service).

This study suggests that a strong understanding of Chinese landscape perception is clearly not delineated and may require a careful examination of the possible regressors that may be affiliated with landscape preference. The Chinese respondents appear to show some of the values that Westerners may have; however, apparently the Chinese respondents may be evaluating the images with a different set of values.

Figure 5. This image also scored very well by French respondents. In addition, this image also scored well with North American respondents (courtesy of the United States National Park Service). The animals in the image are North American Elk (*Cervus canadensis* (Erxleben, 1777)).

It appears that the French and North American respondents have relatively similar preferences. Figure 4 presents an image that is highly preferred by both French and North American respondents. The image is a view of the landscape near and around Rocky Mountain National Park in Colorado, on the west side of the Front Range. The image has foreground, mid-ground and background features, including mountains and a small pond. There are no man-made features in the image. Figure 5 presents another image highly preferred by French respondents. This image is also of Rocky Mountain National Park in Colorado, but on the East side of the Front Range. The image contains North American elk (Cervus canadensis (Erxleben, 1777)). American respondents also rate this image quite favorably.

Figure 6. This image scored very poorly with French respondents (Copyright 1988 © Jon Bryan Burley, all rights reserved, used by permission).

One of the images that was very poorly rated by French respondents was an image of a famous park in Seattle, Washington (Figure 6). This image shows two people descending stairs amongst concrete forms that were inspired from rock formations in the Cascade Range of Washington. The park site is an award winning project and the image is relatively typical of the type of environments found in the park. Yet the image scored poorly. In many respects the response of the French participants is similar to preferences examined in paintings by Joliet et al., where they studied the images of the Portuguese Montado [14]. In this Portuguese landscape, admired paintings were of oak trees and rolling hills with urban and human artifacts only revealed in the distance.

Figure 7 presents an image highly preferred by Portuguese respondents. The image is of the Mummy Range on the north side of Rocky Mountain National Park, Colorado. In the foreground are trees in the South Fork of the Cache la Poudre River floodplain. The site is in Pingree Park, a field station campus for Colorado State University. This image faired well with French and North American respondents.

Figure 7. This image of Rocky National Park from the South Fork of the Cache la Poudre River in Colorado scored very well by Portuguese respondents (Copyright 1990 © Jon Bryan Burley, all rights reserved, used by permission).

Figure 8 presents an image that was very poorly rated by Portuguese respondents. It is the site of an urban demolition project in a major city in the United States of America. This image rates somewhat poorly with French, Chinese, and North American respondents. Figure 9 is also an image that scored quite poorly with Portuguese respondents. This location is a site devastated by a wildfire in the Western United States. The site has damaged timber and exposed soils. This image also rated somewhat poorly across all cultures/nationalities examined. This response is similar to examples where research is being conducted in the Iberian Peninsula to stabilize exposed soils [15]. Research studies indicate that exposed foreground soils create poor impressions of the environment by respondents [1].

Figures 10 is an image of an industrial and warehouse site in a major North American city which will actually become the site of a sports stadium. The condition of the site in the image resulted in North American respondents rating this image as having poor visual /environmental quality. French and Chinese rated this image quite poorly too, while

Chinese respondents also rated this image as containing poor visual/environmental quality. Again the Portuguese respondents rated the image with a much more neutral stance.

Figure 8. This image illustrating a site demolition project in a major American city was rated as having poor visual/environmental quality by Portuguese respondents (Copyright 1979 © Jon Bryan Burley, all rights reserved, used by permission).

Figure 10. This image of a location in a major North American city rated very poorly by North American respondents (Copyright 1979 © Jon Bryan Burley, all rights reserved, used by permission).

Figure 11. This image of utility pedestals in Colorado was rated by North American respondents as having very poor visual/environmental quality (Copyright 1988 © Jon Bryan Burley, all rights reserved, used by permission).

Figure 9. This image of a post-wildfire setting in a National Park located in the United States of America was rated as having very poor visual/environmental quality by Portuguese respondents (courtesy of the United States National Park Service).

Portuguese rated such an image as having a somewhat neutral visual/environmental quality. Figure 11 was the least preferred image by North American respondents. French and

The French and Portuguese equations have a lower explained variance than the North American studies. However, the North American studies have sampled more replications of the images, approximately triple the number. And when the North American respondents are divided into small respondent subsets, the proportion of variance explained becomes similar to the French and Portuguese responses. With an increase in replications, the French and Portuguese investigations might yield a higher proportion of the explained variance. An increase in replications with the Chinese respondents may not increase the proportion of variance explained as the necessary regressor variables may not yet be identified to yield stronger, more definitive results.

In the future, it may be possible to generate an overall North American/European predictive model. But as yet, it is doubtful that a North American/ European/ Asian universal model is possible.

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