The influence of newly built high-rise buildings on visual impact assessment of historic urban landscapes: a case study of Xi’an Bell Tower

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ABSTRACT
For a developing country with monument, how to balance urban development and historical buildings protection in the process of urbanization is a key issue worthy of exploration. Xi’an Bell Tower, located in Xi’an city, Shaanxi province, China, is representative of Chinese historic buildings. Aiming at investigating the public’s visual impact assessment of this representative historic building as well as its surrounding urban landscapes, this study chose one newly built high-rise building in the surroundings of Xi’an Bell Tower as research object and set its height, top, and color as the physical properties; meanwhile, the height limit data in the current government regulations were set as the reference object of height. Simulation experiments were conducted to respondents of different demographic characteristics, randomly selected around the Bell Tower, and the statistical data collected, including the scores rated by interviewers and the demographic characteristics of the interviewers, were analyzed. The results indicate that the height, top, and color of the newly built high-rise building all are influence factors for the public’s visual impact assessment of Xi’an Bell Tower; people of different demographic characteristics assess this historic district landscape differently. This study could be of valuable reference for the future planning of historic buildings’ surroundings.

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1. Introduction

The simplest definition of a historic building is that related to three essential attributes: to be considered “historic”, a property must have sufficient age, a relatively high degree of physical integrity, and historical significance (Mazzarella 2015), architectural heritage is an important part of historic urban landscapes (HUL) (Hussein, Stephens, and Tiwari 2020; Amoruso 2016), recommendation adopted by UNESCO. As the important material and cultural wealth of mankind, historic buildings possess great artistic and historical values. Similarly, it is of undeniably tremendous value in terms of scientific research. Many cities in the world have realized the importance of urban protection in the process of globalization and are trying to promote the urban development based on urban heritage (Sirisrisak 2009). Heritage Impact Assessment (HIA) Guidelines adopted by ICOMOS, heritage and impact assessment has become an important study method of city planning and Urban design (Ashrafi, Kloos, and Neugebauer 2021; Yahampath 2014; Roder and Bandarin 2019). The investigation of the urban planning for the development of surrounding environment around historic buildings in some Chinese cities has revealed two diametrically different urban planning practices. One is the overdevelopment of surrounding environment around the historic buildings so as to maximize its commercial value. But this practice would have the historic building totally immersed in the surrounding high-rise buildings, which may diminish the historic building’s role in the given context: to be the visual focus. The other practice is the overprotection of historic buildings, which exerts tough restrictions upon the architectural form around the historic building for the purpose of amplifying its visual and aesthetic values. But this practice fails to develop its economic values reasonably.

With the development of China’s globalization, it has been a necessity for the historic buildings to integrate into the modern urban environment. However, at the same time, the rapid urban development and improper protection measures pose greater threat on historic buildings than ever before (Najd et al. 2015). Sirisrisak (2009) observed that historic buildings should be considered as the foundation of urban planning and development projects. The public opinions should in no way ignored in the process of drafting urban planning scheme(Yuen 2005). Therefore, it is of significance to study the public’s visual impact assessment of urban landscapes which integrate the historic buildings with surrounding newly built high-rise buildings.

1.1. Background introduction

Xi’an Bell Tower, built in A.D. 1384 and located in Xi’an, Shaanxi province, China, is the biggest, the oldest and best preserved among all the bell towers existing in China now (Yu 2009). As one of the key historic buildings, it was listed as the national key cultural relics protection unit in 1996. As an ancient tool for reporting time, the Xi’an Bell Tower was built in the center of the city. It is a business card of the city of Xi’an, an important landmark building that embodies the historical and cultural heritage of Xi’an and the image of the city. Chinese and foreign tourists must visit it whenever travel to Xi’an. Covering an area of 1,377 m² and 36 m above the ground, Xi’an Bell Tower is composed of three parts: the base, the tower body, and the pyramidal hipped roof. The square base, made of black bricks, is 35.5 m long in each side, and 8.5 m tall, with a 6 m × 6 m vaulted doorway on each side. The tower body is a two-story wood structure with a square plane. Enveloped by a ring corridor, it is three-bay in both width and depth. The pyramidal hipped roof is structured with cornered beam and well-head square-column, a typical open-framed construction, that is, there is no ceiling and all the structural members that support the roof are exposed (Chen, Qianfeng, and Dong 1998). The whole tower is a column-and-ri wooden construction with a three-story pyramidal hipped roof supported by dougong (Figure 1). The rooftop is gilded and the eave is covered with dark green glazed tiles. In China, Xi’an Bell Tower is of great historical and cultural significance.

For many cities, the historic Bell Tower is a remarkable architectonic element and urban icon (Nistico et al. 2016). For the purpose of preserving the aesthetic values of these historic buildings, tough restrictions are implemented upon the construction and reconstruction of the surrounding buildings. The urban planning usually sets up

![Figure 1. Xi’an Bell Tower (Wang 2015).](image-url)
a height restriction on the modern buildings around the historic buildings under key protection. In Xi’an, the Regulations on Restricting the Height of Buildings in Urban Area enacted in 1980 explicitly stipulates that the Xi’an Bell Tower is under key protection. Accordingly, the height of surrounding buildings should be regulated in accordance with the protection range and actual situation. Since the height of Xi’an Bell Tower is 36 m above the ground, the height of surrounding buildings inside the City Wall is set at eight height levels: 36, 28, 24, 21, 18, 15, 12, and 9 m. As for which height level a building should be at, it is decided by its distance to the Bell Tower. To be specific, the closer a building is to the Bell Tower, the lower it is to be built. The height of buildings closest to the Bell Tower is no higher than 9 m. The plane distance between each height level is about 50–60 m. A small number of high-rise buildings can be designed within the area where high-rise buildings are feasible. According to the statistics, the buildings centering around the Bell Tower are no higher than the Tower. For example, the height of Bell Tower Restaurant is 31 m, while both Posts and Telecommunications Plaza and Kaiyuan Shopping Mall are 32 m high.

1.2. The influence of surrounding buildings on urban landscape dominated by historic buildings

The factors that influence people’s preference on the environment can be divided into two categories: the physical characteristics of buildings and environmental factors. The change in the surroundings of a certain building can exert certain influence on its visual impact assessment. In the context of rapid urban development in China, the surrounding environment of many urban landmarks is constantly changing (Z. Wang 2018). Some high-rise buildings are also built near Xi’an Bell Tower. Cohen (1999) maintained that high-rise buildings were crucial to urban space and that to regulate the building height was beneficial to urban landscape protection. The newly emerging high-rise buildings influence the city and its downtown in various ways, especially the urban landscape dominated by historic buildings (Short 2007).

It is widely used in academic papers to induce the characteristics of research objects through literature review (Kalivoda et al. 2014; Wang and Zhao 2017). Therefore, through literature review, the characteristics of buildings surrounding Xi’an Bell Tower in this study are divided into four types: volume, height, top, and color.

1.2.1. Height

Yabuki, Miyashita, and Fukuda (2011) used the AR method to study the integration of different building heights with the surrounding landscape. The results showed that the sense of the lake got the highest pleasure value, when the width of the lake is 0.2 km, the lake landscape with the height of the building not exceeding the contour line of the trees. Pleasure values drop sharply when buildings are three times the height of trees, because the height reduces the overall harmony with the surroundings and reduces visual comfort. Sadeghifar, Pazhouhanfar, and Farrokhzad (2019) found that proportion (height, width, etc.) has a significant effect on people’s preference for buildings, in a study of the correlation between visual elements of urban architecture and people’s preferences. The study believed that scale and proportion of the building can also be viewed as visual factors that influence public preferences for buildings.

1.2.2. Top

Samavatekbatan, Gholami, and Karimimoshafer (2016) using computer software to change the height, roof shape and color of a particular building, the aesthetic problems of architecture are studied. He found that the complexity of the building’s roof influence people’s evaluation of visual preferences for its exterior. Oh et al. (2008) analyzed 147 apartments’ roofing styles in a city in South Korea to determine people’s preference for apartment’s roof style. The results show that people have a high preference for images of stable roofs.

1.2.3. Color

Sadeghifar, Pazhouhanfar, and Farrokhzad (2019) took a city building in Iran as an example, eight factors, including shape, color, decoration, material and roof, were set as its preference evaluation variables, and a photo questionnaire survey was conducted among student volunteers in a university. The results showed that shape, color and proportion have significant influence on people’s preferences, and color is considered to be the most significant variable that can influence people’s preferences. In the study of Chen and Cabrera (2021), 30 volunteers were asked to assess the impact of different colors of a concert hall on their visual preferences, by using a virtual reality scenario. The results showed that people’s visual preferences were red, grey, blue, yellow and green, from the highest to the lowest of five colors tested.

1.3. Visual impact assessment, from physical to socio-demographic approach

Undoubtedly, historic buildings are greatly valuable. As one type of urban landmarks, historic buildings embody immeasurable aesthetic values (Brown 2006). Yahampath (2014) observed that Public participation is an essential method in heritage impact assessment. Public opinion can not be ignored in the development of urban protection planning programmes. When assessing the visual impact of different elements in artificial and natural environment, researchers would usually adopt the method of visual impact assessment (Hernández, García, and Ayuga 2004).
Although this method – to study the public’s visual impact assessment by displaying some photos to the viewers – has some limitation (Daniel 2001; Palmer and Hoffman 2001; Steinitz 2001), it is still considered the most widely used and most effective method for aesthetic evaluation (Barrosaaba 2012; Daniel 2001). In the previous studies, photos are widely used as a substitute for the actual landscape. Stamps lll (1990) observed that for common people, there was a highly positive correlation between the visual information they obtained from static colored photos and that from actual view. Abello and Bernardíez (1986), Kaplan and Kaplan (1989), (Hami, Moul, and Maulan 2018), Ng et al. (2015), Eimawati (2016) used photos as substitute to the actual landscapes to investigate the respondents’ visual impact assessment.

Two main paradigms are available for landscape evaluation: objective paradigm and subject paradigm (Daniel 2001; Zube, Pitt, and Evans 1983). The former maintains that beauty is internalized to the landscape, whereas the latter argues that beauty is a subjective or psychological domain, the product of many visual organs (Lothian 1999). This participatory or psychophysical method (Molnarova et al. 2012) evaluates different types of landscapes according to people’s preference. In other words, the visual impact assessment is the product of the interaction between landscapes’ biophysical characteristics and human viewers (Lothian 1999; Molnarova et al. 2012; Strumse 1996). Similarly, the individual differences need to be considered as well. The differences in economic, social, physical, and psychological aspects would cause the variation of visual preference.

Although there are several studies which have proved that regardless of the individual elements, there exists some similarity in respondents’ visual preference (Cam, Ayuga, and Ayuga 2009; De Val and Mühlauser 2014), it is universally accepted that demographic characteristics definitely influence people’s visual impact assessment of landscapes. Of all the demographic characteristics which have been defined and acknowledged, the following ones are mostly and usually studied: cultural background (Yu 1995), education (López-Martínez 2017; Svobodova et al. 2012), gender (Strumse 1996), age (Yamashita 2002), professional knowledge (Strumse 1996; Vouligny, Domon, and Ruiz 2009), place of residence (Misgar 2000; Wendel, Zarger, and Mihelic 2012), and living environment (Yu 1995). This study only took four of these characteristics into consideration: age, gender, education, and place of residence. The first three attract the most academic concern in the study of landscape preference (López-Martínez 2017).

1.4. Research purpose

In the process of urbanizing cities worldwide, new buildings will pose threats on the preservation of urban landscape dominated by historic buildings. In addition to the simple method of mandatory height
limits for surrounding buildings, whether there are other ways to avoid irreversible damage to the architectural heritage and to achieve a balance between the protection of the architectural heritage and urban development, this is the focus of this study.

Through concerning the visual impact assessment in the heritage impact assessment, to study the physical properties which influence the visual impact assessment of historic buildings, a mixed method was employed: the visual characteristics of objective objects are combined with the respondents' subjective psychological assessment. This study aims to realize the following purposes: to prove whether the surrounding newly emerging high-rise buildings would influence the public's visual impact assessment of the historic district landscape of Xi'an Bell Tower; to come up with a solution to assess how the physical properties of the newly built high-rise buildings around the historic buildings affect the public's visual preference for the urban landscape of the historic district; and finally to evaluate the differences in visual impact caused by the four demographic characteristics (age, gender, education, and place of residence) by way of large-scale public participation.

2. Method

2.1. Location of photo shooting

The research materials of this experiment are the photos of the overall scene of Xi'an Bell Tower and its surrounding buildings. The high-rise building chosen in the experiment is located in the southeast corner of Xi'an Bell Tower, at a linear distance of about 420 m to the tower. It is an actual four-star hotel construction project undertaken by our design team, which is currently in the early planning and research stage. Xi'an Bell Tower is located at the intersection of four avenues. In its due east, due west, due north, and due south, there are four avenues; in its southwest stands Bell Tower Restaurant; in its northwest is Bell-Drum Tower square; in its southeast erects Kaiyuan Shopping Mall; and in its northeast stands Posts and Telecommunications Plaza. To the southwest, southeast, and northeast of Xi'an Bell Tower are all high-rise buildings, which are close to the Xi'an Bell Tower. Consequently, there is no enough visual distance to observe the whole view of Xi'an Bell Tower and its surrounding buildings in these three directions. By contrast, the square in the northwest offers an excellent view, which is easy to observe and study. Therefore, Century GINWA Square which is located to the northwest of Xi'an Bell Tower (as shown in Figure 2) was selected to be the site for photo shooting; and all the other observation points were abandoned in that they cannot represent the overall scene of Xi'an Bell Tower and its surrounding buildings. As the only square where Xi'an Bell Tower can be observed at short distance, Century GINWA Square offers an excellent observation site for a full view of Xi'an Bell Tower and its surrounding buildings (as shown in Figure 3). At the same time, it is also the most commonly used and the best observation site with the widest horizon.

2.2. Photo shooting

In late March 2020, 20 photos were taken with a SONY A7M2 digital camera at the observation site selected on a sunny day. These photos were taken at the same focal length and viewing angle, without any special filter, effects or any other digital operation which may distort the content (Barrosoaabaa 2012). In the process of photo shooting, the camera was fixed at 160 cm above the ground with a tripod to simulate the height of human eyes to the ground, since as the Report on Nutrition and Chronic Diseases of Chinese Residents (2015) goes, the average heights of Chinese man and woman are 167.1 and 155.8 cm, respectively.

2.3. The physical characteristics of surrounding high-rise buildings

The experiment was designed to study the influence of height, volume, top, and color of observed buildings on visual impact assessment of Xi'an Bell Tower and its

Figure 3. The overall scene of Xi'an Bell Tower and its surrounding buildings.
surrounding buildings. However, it was discovered in the field investigation that due to the limitations of site area and plot ratio of the construction project, the volume change of buildings to be measured in this study was decided by its height change. Therefore, this study did not consider this characteristic. Meanwhile, control variable method was used to divided height, top, and color into three levels (Table 1).

(1) Height: The plane distance between the measured building and Xi’an Bell Tower is about 420 m. According to the height control norms, the height limit of constructions in this lot is 36 m. Therefore, with 36 m (the height of Bell Tower) as reference, the height of surrounding buildings can be divided into three levels: 36 m (equal to the height of Bell Tower, the height ratio: 1); 54 m (relatively higher than the height of Bell Tower, the height ratio: 1.5); 72 m (twice as high as Bell Tower, the height ratio: 2).

(2) Top: To define different types of building top, this experiment selected the most common types of building top in Xi’an city. Three types of building top were set in this experiment, namely, Chinese slop roof, modern flat roof, and European pitched roof.

(3) Color: Through preliminary investigation, white and light yellow were chosen from the existing surrounding buildings on the ground that they were used highly frequently; dark gray was set as color variable for the Bell Tower in that it was used remarkably.

2.4. Photo processing
The 20 photos of the overall scene of Xi’an Bell Tower and its surrounding buildings were sent to five architectonic experts who were asked to single out one photo which represented the overall scene of Xi’an Bell Tower in a satisfactory manner. Then the most-selected photo was chosen to be processed for the experiment. By means of Sketchup 2018, the physical characteristics were adapted to meet the demand of each building model. In total, 27 models were established in terms of the three characteristics (height, top, and color). Then Vray was used to render the models. The rendered models were fused with the most-selected photo by means of Photoshop to achieve the visual effect which the actual landscape would present to the viewers (Dupont et al. 2017).

2.5. The investigation of respondents’ preference
As is stated above, the as-prepared 27 pictures represent the different heights, volume, top, and colors of the surrounding buildings. These pictures were printed in full color, bound into a volume in random order, and then shown to the respondents. For the convenience of respondents’ scoring the pictures, the 27 pictures were printed on nine pieces of A4 paper, with three pictures a piece (as shown in Figure 3). Then, these pictures were displayed to the respondents chosen randomly on the street who were asked to score the overall scene of Xi’an Bell Tower and its surrounding buildings shown in the pictures. The experiment was conducted at the weekend so as to avoid the oversingleness of demographic characteristics of the respondents. In the previous relevant studies, pictures have been widely used to substitute the actual landscapes (Norouzian-Maleki et al. 2018), which justifies the practice of using pictures to conduct visual impact assessment.

Firstly, the respondents in this experiment were asked to complete the questionnaire which covered their demographic characteristics, namely, gender, age, education, and place of residence (as shown in

| Table 1. Physical characteristics statistical. |
|-----------------------------------------------|
| Physical properties | Levels       |
| Height             | 36 m; 54 m; 72 m |
| Top                | Chinese slop roof; Modern flat roof; European pitched roof |
| Color              | White; Yellow; Dark gray |

| Table 2. The variables of demographic characteristics and corresponding set values. |
|-----------------------------------------------|
| Demographic characteristics | Variable | Set value |
| Gender                         | Female   | 1         |
| Age (years)                    |          |           |
| 18–34                          | 1        |
| 35–59                          | 2        |
| ≥60                            | 3        |
| Education                      |          |           |
| With a higher education        | 1        |
| Without higher education       | 2        |
| Place of residence             |          |           |
| Xi’an                          | 1        |
| Other places                   | 2        |

| Table 3. The implication of picture values. |
|---------------------------------------------|
| Value | Implication             |
|-------|-------------------------|
| 1     | Very dislike            |
| 2     | Mild dislike            |
| 3     | Neutral                 |
| 4     | Mild like               |
| 5     | Very like               |

| Table 4. The demographic characteristics of respondents. |
|----------------------------------------------------------|
| Demographic characteristics                  | Variable | Number of respondents | Percentage of respondents |
| Gender                                      | Female   | 168                   | 43.41                     |
|                                             | Male     | 219                   | 56.59                     |
| Age (years)                                 |          |                       |                           |
| Between 18 and 34                          | 148      | 38.24                 |
| Between 35 and 59                          | 137      | 35.40                 |
| Education                                  |          |                       |                           |
| Receive higher education                   | 173      | 44.70                 |
| Receive no higher education                | 214      | 55.30                 |
| Place of residence                         |          |                       |                           |
| Xi’an                                      | 267      | 68.99                 |
| Other places                               | 120      | 31.01                 |
Table 5. Multifactor variance test on subject effect intersubject effect test.

| Source             | Ill type quadratic sum | Degree of freedom | Mean square | F     | Significance |
|--------------------|------------------------|-------------------|-------------|-------|--------------|
| Correction model   | 34.128                 | 17                | 3.281       | 153.972 | .000         |
| Intercept          | 3692.210               | 1                 | 3604.284    | 223,987.828 | .000        |
| H                  | 27.221                 | 5                 | 7.117       | 474.218 | .000         |
| T                  | 4.186                  | 6                 | .442        | 27.221 | .000         |
| C                  | .312                   | 4                 | .041        | 2.412  | .035         |
| Error              | 4.115                  | 242               | .023        |        |              |
| Total              | 3512.324               | 285               |             |       |              |
| Total after correction | 36.318         | 274               |             |       |              |

*R square = 0.642 (after correction, R square = 0.615).

Table 2). Gender refers to male or female; education refers to with/without a higher education; Xi'an Bell Tower is an important tourist attraction for domestic and foreign tourists. Considering that local residents and foreign tourists may have different feelings towards Xi'an Bell Tower, place of residence means where the respondents live, in Xi'an or other places. In consideration of the need to protect juvenile’s privacy, this experiment did not take juveniles as qualified respondents. Therefore, the variable “age” was divided into three groups (18–34; 35–59; and ≥60 years). Then the respondents were asked to score the 27 pictures according to their own visual preference. The score range was from 1 to 5, with 1 representing the lowest score and 5 the highest. They could change their scores as they wished before the end of experiment (Dramstad et al. 2006). The questionnaire investigation was mainly conducted between May and June 2020. In total, 463 respondents were surveyed and 387 valid questionnaires were collected, with the validity rate reaching up to 83.58%. The demographic characteristics are basically consistent with the population distribution characteristics of the sixth national population census. The implication of picture scores was shown in Table 3, and the demographic characteristics of respondents are given in Table 4.

The data collected were analyzed with SPSS 22.0 to investigate the influence of different demographic characteristics on the visual impact assessment of the height, volume, top, and color of the selected buildings surrounding Xi’an Bell Tower. Then, multiple linear regression analysis was conducted to further study the influence. These analytical methods have been widely used in the previous studies (Wang and Zhao 2017).

2.6. Data analysis method

The average scores of the collected photos were statistically analyzed using SPSS 22.0 software. First, one-way ANOVA was used to check the three physical properties’ effect on respondents’ preference. Second, stepwise multiple linear regression analysis was used to search the qualitative relationships between the three physical properties and the respondents’ preference, and the quantitative relationships between the three physical properties and the demographic characteristics. These analytical methods are widely used in similar studies.

3. Results

3.1. The overall assessment of pictures

Firstly, the inter-group reliability of the 27 pictures was tested. As is stated previously, these pictures represent the various combinations of height, volume, top, and color of the surrounding buildings. By means of SPSS 22.0, the reliability was calculated to be 0.757, a relatively high internal reliability. Thus, it can be concluded that the questionnaire survey and the data obtained were reliable for the following detailed analysis.

The average score of each picture was denoted by S. Of all the pictures, the highest average score was 3.79 and the lowest 2.63 (the score range: 1–5). The average score of all pictures was 3.36. The pictures which were scored higher are shown in Figure 4, a 54-m light yellow Chinese slop-roofed building, a 54-m white modern flat-roofed building and a 36-m white modern flat-roofed building; the pictures with the lower average scores were that of a 72-m dark gray building with a European pitched roof, a 72-m light yellow building with a modern flat roof and a 36-m white building with a European pitched roof as are shown in Figure 5.

In the experiment where pictures are used to substitute the actual landscapes, the average score of a picture can be considered as the valid data to reflect the respondent’s visual impact assessment (Wang et al. 2019).

3.2. The relationship between height, top, color and visual impact assessment

Multifactor variance analysis was conducted to study the relationship between the height, top, color of surrounding buildings and respondent’s visual impact assessment. To be specific, the height of surrounding buildings was denoted by H, top by T, color by C. Then, they were set as the factors while the average score of each picture S was set as a dependent variable.

As is shown by multifactor variance analysis in Table 5, the model (F = 153.972, P = 0.000) is meaningful in the
overall sense. Meanwhile, the model fitting number (denoted by R square) is equal to 0.615, indicating that the model is suitable for the data obtained from the questionnaire survey. Therefore, according to SPSS analysis, the original assumption is denied. In other words, significant difference exists at least in one of the three factors (namely, H, T, and C). Further calculation and analysis confirms that significant difference exists in all the three factors, with H \((F = 474.218, P = 0.000)\), T \((F = 27.221, P = 0.000)\), and C \((F = 2.412, P = 0.035)\). Accordingly, it can be concluded from multifactor variance analysis that when the average score is set as dependent variable, significant difference can be observed in the height, top, and color of the surrounding buildings. To put it another way, the height, top, and color of the surrounding buildings are the factors that influence the average score of pictures.

### 3.3. Respondents’ demographic characteristics and visual impact assessment

First, one-way ANOVA was conducted to study the relationship between demographic characteristics and visual impact assessment. As the calculation indicates, significant difference exists in the average scores given by
respondents whose demographic characteristics are as follows: gender difference ($F = 8.652, p = 0.000$), age difference ($F = 4.128, p = 0.020$), place of residence ($F = 7.215, p = 0.042$), and education difference ($F = 5.211, p = 0.000$).

Then, Kendall correlation analysis was conducted to re-examine the correlation between demographic characteristics and visual impact assessment. As is shown in Table 6, there is significant correlation between the average score $S$ and gender (negative correlation), age (positive correlation), education (negative correlation), and place of residence (positive correlation).

Finally, the data obtained were further analyzed by means of multiple linear regression model. In the model, gender, age, educational background, and place of residence are taken as independent variables whereas the average score of photos is set as the dependent variable. The analysis results indicate that gender, age, educational background, and place of residence exert significant influence on picture assessment (as shown in Table 7).

Further analysis was conducted to explore whether there is reciprocal effect among demographic characteristics. Collinearity analysis was done to the independent variables with the results of multiple linear stepwise
regression analysis. The tolerance of meaningful independent variable is 0.482, with VIF = 3.689. The tolerance of age is 0.82, with VIF = 1.369; that of education is 0.486, with VIF = 3.312; the tolerance of place of residence is 0.993, with VIF = 7.145. When the VIF of a model is larger than 10 or its tolerance is smaller than 0.2, the model suffers collinear problems (Arriaza, Cañas-Ortega, Cañas-Madueño, & Ruiz-Aviles 2004; Menard 1995). According to the SPSS calculation, the VIFs of all the independent variables are smaller than 10 and the tolerances are larger than 0.2. Besides, the residual is distributed normally. Therefore, it can be concluded that this model does not have any collinear problem.

### 3.4. Respondents’ demographic difference and the pictures’ physical properties

The average score of each picture given by different demographic characteristics of the respondents were set as dependent variables. The physical properties of the 27 pictures (H, T, and C) were set as independent variables. As the multiple linear stepwise regression models show, the significant predictors for respondents of different genders, ages, educational backgrounds and places of residence are different (as shown in Table 8). For male, H and T are reliable predictors of visual impact assessment; whereas for female, T and C are reliable predictors. For respondents aging from 18 to 34, T and C are reliable predictors of visual impact assessment; for
Table 7. Multiple linear stepwise regression analysis.

|                | Unstandardized coefficients | Standardized coefficients | Collinearity Statistics |
|----------------|-----------------------------|--------------------------|------------------------|
|                | B                           | Std. error               | Beta                   | t          | Sig. | Tolerance | VIF |
| (Constant)     | 3.582                       | 0.04                     | 15.962                 | 0.000     |      | 0.82      | 1.369 |
| Age            | 0.36                        | 0.018                    | 0.852                  | 4.992     | 0.032 | 0.482     | 3.689 |
| Gender         | -0.52                       | 0.018                    | -1.678                 | -7.167    | 0.000 | 0.486     | 3.312 |
| Educational background | -0.698                   | 0.08                     | -0.896                 | -3.69     | 0.028 | 0.486     | 3.312 |
| Place of residence | 0.63                    | 0.019                    | -1.82                  | -7.723    | 0.000 | 0.993     | 7.145 |

Table 8. Multiple linear regression analysis of the pictures’ physical properties for different gender groups.

| Dependent | Unstandardized coefficients | Standardized coefficients | t          | Sig. | Tolerance | VIF |
|-----------|-----------------------------|--------------------------|------------|------|-----------|-----|
|           | B                           | Std. Error               | Beta       |      |           |     |
| Scores for male |                              |                          |            |      |           |     |
| (R² = 0.62, N = 219) |                              |                          |            |      |           |     |
| H         | 0.432                       | 0.027                    | 0.945      | 3.23  | 0.002     | 1.29 |
| T         | 1.562                       | 0.821                    | 1.861      | 2.321 | 0.023     | 1.39 |
| Scores for female |                              |                          |            |      |           |     |
| (R² = 0.53, N = 168) |                              |                          |            |      |           |     |
| H         | 0.963                       | 0.318                    | 0.931      | 4.121 | 0.001     | 0.718 |
| C         | 2.012                       | 0.722                    | 0.639      | 1.632 | 0.000     | 0.641 |
| 18–35 years old (Constant) | 6.982                   | 0.325                    | 5.029      | 0.001 | 0.459     | 3.158 |
| R² = 0.638, n = 148 |                              |                          |            |      |           |     |
| H         | 0.351                       | 0.698                    | 0.478      | 5.861 | 0.001     | 0.491 |
| C         | 1.298                       | 0.254                    | 1.321      | 3.985 | 0.006     | 0.914 |
| 36–59 years old (Constant) | 7.492                   | 0.375                    | 4.802      | 0.001 | 0.625     | 5.263 |
| R² = 0.618, n = 137 |                              |                          |            |      |           |     |
| H         | 8.982                       | 0.618                    | 6.074      | 0.001 | 0.541     | 4.209 |
| 60 years old or older (Constant) | 0.592                  | 1.653                     | 0.715      | 4.755 | 0.001     | 0.519 |
| R² = 0.691, n = 102 |                              |                          |            |      |           |     |
| H         | 3.698                       | 0.267                    | 5.126      | 0.001 | 0.519     | 4.209 |
| 60 years old or older (Constant) | 3.698                  | 0.267                     | 5.126      | 0.001 | 0.519     | 4.209 |
| R² = 0.687, n = 173 |                              |                          |            |      |           |     |
| H         | 0.365                       | 2.569                    | 0.698      | 4.148 | 0.000     | 0.521 |
| C         | 0.306                       | 1.878                    | 0.784      | 3.872 | 0.001     | 0.493 |
| Without higher education (Constant) | 0.279                  | 2.603                     | 0.507      | 4.609 | 0.026     | 0.578 |
| R² = 0.382, n = 214 |                              |                          |            |      |           |     |
| H         | 4.754                       | 0.374                    | 4.325      | 0.000 | 0.474     | 3.524 |
| Xi’an (Constant) | 6.158                   | 0.352                     | 6.982      | 0.001 | 0.367     | 6.258 |
| R² = 0.698, n = 267 |                              |                          |            |      |           |     |
| H         | 0.426                       | 2.698                    | 0.312      | 4.021 | 0.026     | 0.357 |
| T         | 0.664                       | 1.482                    | -0.398     | 4.812 | 0.021     | 0.521 |
| Without higher education (Constant) | 0.428                  | 1.769                     | 0.621      | 3.859 | 0.001     | 0.435 |
| Other places (Constant) | 5.812                   | 0.493                     | 5.932      | 0.001 | 0.521     | 4.528 |
| R² = 0.539, n = 120 |                              |                          |            |      |           |     |
| H         | 0.471                       | 1.052                    | 0.428      | 4.747 | 0.000     | 0.782 |
| C         | 0.548                       | 1.324                    | 0.557      | 4.820 | 0.010     | 0.683 |

Respondents aging from 35 to 59, C is the reliable predictor; for respondents over 60 years old, H is the reliable predictor of visual impact assessment. For respondents who receive higher education, H, T and C are reliable predictors of visual impact assessment; whereas for respondents without receiving higher education, T is the reliable predictor. For respondents who live in Xi’an, H, T and C are reliable predictors of visual impact assessment; whereas for respondents who live in other places, H and C are the reliable predictors.

K-S test was conducted to verify if there exists any collinearity between models. The calculation indicates that the residual distribution of models is normal. Thus, it can be safely drawn that there is no collinearity between models.

4. Discussion
4.1. Demographic characteristics and visual impact assessment

Analyzing the correlation between demographic characteristics and visual impact assessment by means of multiple linear regression model, gender, age, educational background, and place of residence exert significant influence on picture assessment. It was found that there isn’t any reciprocal effect between the four demographic characteristics selected for this study, namely, gender, age, education, and place of residence (as shown in Table 7).

Zube, Pitt, and Evans (1983) held that different demographic characteristics would lead to different visual impact assessment, even on the same group of pictures. Meanwhile, they also discovered that the average score would decline as the age of respondents increased. However, this experiment came up with a different result: the lowest average score was given by the middle-aged group (as shown in Table 6). This result is mainly caused by the fact that the aged respondents pay more attention to Xi’an Bell Tower itself, which weakens the influence brought forth by the changes of physical properties of surrounding buildings. In this case, the average score given by the aged group is generally higher than the other two groups. Meanwhile, the young respondents are witnessing the rapid development of Chinese urbanization and thus are more acceptant to diverse architectural forms. Accordingly, the average score given by the young respondents is also relatively higher. Howley, Donoghue, and Hynes (2012) claimed that people of
different ages would produce different visual impact assessments. The reason for this difference consisted in the multi-fold influence of respondents’ living environment and experience. This is also true of the conclusion of the current study. Therefore, when judging the visual impact assessment of different age groups, it is advisable to further consider the respondents’ cultural background and living environment instead of rushing to a conclusion.

Wang and Zhao (2017) observed that gender difference would lead to different visual impact assessment, which is consistent with this study. Abello and Bernáldez (1986) observed that gender difference will lead to different visual preference evaluation for urban green vegetation landscape. Howley (2011) found the similar results in their study. Meanwhile, this study also discovered that male respondents would assess the landscape more highly than their female counterparts. To be specific, the average score given by female respondents is 3.24 while that by male respondents is 3.65. This may be justified by the fact that the building to be assessed takes up a relatively small proportion of the whole picture of Xi’an Bell Tower and its surrounding buildings and that males attach more importance to the overall effect the picture.

López-Martínez (2017) put forward that education exerted some influence on people’s visual impact assessment of landscapes. Lindemann-Mattthies, Junge, and Matthies (2010), Molnarova et al. (2012) put forward that the less educated people would give higher score than the people who are better educated, which is similar to the conclusion drawn by this study. This phenomenon is probably caused by the fact that highly educated people may attach more importance to the protection of historic buildings. Therefore, with maximum respect, they would be stricter when assessing the overall scene of Xi’an Bell Tower and its surrounding buildings. In this case, their visual impact assessment is lower than those without receiving higher education.

Wendel, Zarger, and Mihelic (2012) discovered that place of residence influenced the public’s spatial perception. This study also verified his conclusion. In this study, the native people of Xi’an city scored the pictures much lower than those living in other places did. What’s more, respondents living in Xi’an showed a significant difference in their preference of building height from those living in other places. To be more specific, tourists were more in favor of the buildings under the current height restriction, while the natives of Xi’an preferred a building height which was one time and a half of Xi’an Bell Tower.

All in all, although no consensus has even been achieved in terms of how different demographic characteristics influence visual impact assessment, this study discovered that special consideration should be given to the factors like individual difference, characteristics of the times, respondents’ experience, and regional environment. In this experiment, by means of multi-linear regression model, it was found that there did not exist any reciprocal effect between the four demographic characteristics selected for this study, namely, gender, age, education, and place of residence (as shown in Table 7).

4.2. Demographic characteristics and the pictures’ physical characteristics

Respondents of different genders produced different visual impact assessments of Xi’an Bell Tower and its surrounding buildings (Figure 6). It is found through this experiment that for female respondents, their primary concern goes to the height and color of the surrounding buildings when they assess Xi’an Bell Tower. Moreover, multifactor variance analysis reveals that significant difference exists between 72-m-high buildings and the other two building groups; and the 72-m-high buildings are scored the lowest by female respondents. This may be because females prefer building groups whose height changes slowly whereas the 72-m-high buildings appear to be too abrupt in the pictures. By contrast, male respondents mainly consider the height and top of surrounding buildings when assessing Xi’an Bell Tower and its surrounding buildings. They prefer modern flat roof and the 54-m-high buildings are scored the highest. This is mainly because male respondents prefer modern building appearance and rich skyline shapes.

Respondents of different age groups produced different visual impact assessments of Xi’an Bell Tower and its surrounding buildings (Figure 7). According to this experiment, for the group aging from 18 to 34, they pay more attention to the top and color when assessing Xi’an Bell Tower and its surrounding buildings. Buildings with modern flat roof are scored the highest while dark gray buildings are scored the lowest. The reason for this may consist in the fact that young people are more edified with modern buildings, thus preferring modernism building style. The group aging from 35 to 59 attaches more importance to the height and color of the buildings when assessing these buildings. It can be found through comparing the average scores of each color group that white buildings are scored the highest. This may be because respondents of this age group have a relatively rich life experience, thus giving priority to the overall unity of Xi’an Bell Tower and its surrounding buildings. For respondents over 60 years old, they pay more attention to the height of buildings and prefer the relatively low buildings around Xi’an Bell Tower. The reason for this may consist in the fact that they all have deep affections with Chinese traditional culture and are more willing to highlight Chinese traditional architecture, of which Xi’an Bell Tower is taken as the symbol in
this case. From the above analysis, it can be observed that young people are more inclusive and receptive in terms of architecture, which is not hard to comprehend in the context of China’s rapid urbanization development in the past decades. The newly built buildings are mostly modernistic in style and young people are more open to new things. By contrast, senior respondents are more nostalgic, thus attaching more importance to Chinese traditional culture.

Higher education is also an influence factor to the visual impact assessment of Xi’an Bell Tower and its surrounding buildings (Figure 8). For respondents who receive higher education, their scores fluctuate drastically when assessing Xi’an Bell Tower and its surrounding buildings. The reason for this consists in the fact that they are more adaptable to the ever-changing environment of urban construction and planning. Accordingly, they can produce their own clear judgment on the change of the physical properties of surrounding buildings. By contrast, for those who receive no higher education, they attach more importance to the characteristics of building top in that the building top can influence the overall appearance of the building directly. People without higher education would naturally catch some physical properties which are more visually concrete. To them, the high-rise buildings with a European pitched roof would mess up the whole picture when mixing up with Chinese traditional ancient buildings as well as the surrounding buildings. In addition, it can be observed through comparing the scores given by the two groups that the respondents who receive higher education tend to score the picture relatively lower. This may be justified on the ground that they are stricter with the appearance of buildings surrounding historic buildings, for their cultural and artistic appreciation let them show more respect to the historical status of historic buildings.

Place of residence also influences respondents’ visual impact assessment of Xi’an Bell Tower and its surrounding buildings (Figure 9). Though seemingly against the current height limit on building height surrounding Xi’an Bell Tower, respondents who are Xi’an natives score relatively higher the buildings which break the height limit. The reason for this may lie in that the urban development of Xi’an has been relatively slow and the urban landscape centering on Xi’an Bell Tower has been around for years. In this case, they are more eager and ready to welcome the change of urban appearance. By contrast, for respondents who live in other places, they prefer the buildings lower than the height limit. This may be because they are mostly tourists who come to Xi’an to appreciate the Chinese traditional culture embodied in Xi’an Bell Tower. Accordingly, they do not want to see the surrounding buildings undermining the harmony and unity of Xi’an Bell Tower.

5. Conclusion

The contradiction between urban development and historic buildings protection has ever been existing. New buildings will pose threats on the preservation of urban landscape dominated by historic buildings. In such an era of globalization, it is of great importance for developing countries to avoid any irreversible damage to historic buildings and thus achieve the balance between urban development and historic buildings protection. The experiments conducted in this study about Xi’an Bell Tower and its surrounding buildings reveal that the height restriction issued by Xi’an municipal government has not been implemented satisfactorily. The research results indicate that the visual impact assessment of the height of the new high-rise buildings around the Bell Tower is in connection with many factors; and with the interaction of many factors, the regulation that the newly built high-rise buildings should be no higher than 36 m can be completely changed. Although this finding is beyond expectation, the actual evidence obtained in the experiment proves that these problems are real and may influence the quality of the landscape surrounding historic buildings. The design of a building needs to take many factors into consideration. The case is more complicated for the architectural design in a historic district. Although the ultimate design can not be decided by a single study, this experiment reveals the aesthetic trend caused by demographic differences and the public’s expectation upon the development of surrounding buildings around Xi’an Bell Tower.

For a long time, public participation has been excluded from urban planning in China. The results of this study may not be important or adequate enough to revise the current norms, but it reveals the fact that the public’s visual impact assessment does differ, and verifies the possibility of revising the current urban norms. Attaching importance to public participation and the public’s visual impact assessment can provide new ideas for future urban planning strategies. In the era of globalization, historic buildings with special cultural connotation have been more and more treasured (Yuen 2005). As is discovered in this study, although the decision-makers of urban planning have given enough attention to the historic buildings within the study area, the drawbacks of implementing rigid height restriction upon surrounding buildings still arise in this study. In the current urban planning of Xi’an, the regulation that the buildings around the Bell Tower should be no higher than 36 m fails to embody the diversity and variability of public visual impact assessment. In the future urban planning, the comprehensive effect of
multifactors (such as color and roof form) should be fully considered; public participation should be fully valued; and corresponding urban planning and urban design standards should be formulated so as to better protect and highlight the value of historic buildings. We suggest that visual impact assessment should be considered as an important way of public participation and applied in future urban design, which can better reflect the will of the public.

There are certain limitations in this study. The history of the Xi'an Bell Tower peripheral environmental features in the development of China's urbanization is gradually changing, the existing surrounding the Xi'an Bell Tower is modern architecture. In such a modern city landscape in the research for new high-rise public building with visual preference between the architectural heritage evaluation to research conclusion has brought a certain uniqueness, there may be some limitations. This experiment is aimed at the rapid urbanization in Xi'an large cities, for some small and medium-sized cities in the lower level of urbanization is applicable is yet to be proven. Different architectural heritages of different scales and forms may also have different influences on observers. In addition, the single view point (peripheral planning leads to only one optimal observation point) photos adopted in this study may also result in certain limitations of the research method. However, given that the surroundings of most historic buildings in China has lost its original historical appearance, this study is still of certain reference to the future decision-makers in that it offers a new insight to them as for how to balance urban development and historic buildings protection in the context of urbanization.

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