A study on visual impact assessment of the external form of unified houses in rural China

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ABSTRACT
Under the background of promoting rural revitalization in China, the construction of unified houses has become an important trend of rural development. However, controversy has never ceased over its results. This research set the external form of unified houses as its research object and surveyed forty-two rural unified housing programs distributed in Jiangsu, Zhejiang, and Shandong provinces. Five physical features (namely, building stories, roof type, courtyard area, window-wall ratio, and residential landscape area) were taken as the research dimensions to evaluate the influence of these features on respondents’ visual impact assessment by means of photo stimulation. Through analyzing the data obtained from experiments, the difference of rural families with different demographic characteristics in their visual impact assessment has been explored. The results show that all the five physical features would influence rural residents’ visual impact assessment of the external form of unified house; families with different demographic characteristics also differ in their visual impact assessment. This research provides constructive reference for the better development of unified housing program in rural China.

1. Introduction
1.1. Unified house
As the Chinese economy grows persistently, the contradiction between land for economic development and farmland protection is becoming more apparent (Deng et al. 2020; Wang et al. 2012a, 2012b). As early as 2004, the Chinese Ministry of Natural Resources introduced the policy of reorganizing rural construction land, implementing rural reconstruction and merging villages. However, as one of the specific measures of this policy, the pilot construction of rural unified housing started nationwide only in 2018. The villages with unified housing construction usually need to meet at least one of the following conditions: poor geographical conditions, underdeveloped transportation system, planned demolition due to reconstruction needs, high incidence of natural disasters, small population, scattered layout or unified will of rural people. The county government would select the suitable construction site for building the unified housing and reports it to the Ministry of Natural Resources municipal government for approval. It is a new rural community which is planned, designed and constructed by a professional team entrusted by the county government (Huang 2019). The rural residents receive compensation by selling the original homestead and ancillary buildings, and buy a new house at the cost of construction with the family unit. For the unified housing only aiming at the original farmers in the township area, the type of agricultural registered permanent does not change except for the change of the specific address. The construction of unified housing can provide rural people with better supporting service facilities for daily life and production, improve their living conditions and quality of life. And it can improve rural production efficiency and provide more opportunities for rural people to get rich, so as to increase their income. At the same time, the construction of unified housing can convert the homestead of scattered rural families into cultivated land or building land, which promotes the intensive use of land, reduces the waste of land resources, and has the role of sorting out land resources (Zhang et al. 2018).

The issue of housing is central to rural development concerns; any housing policy for rural areas must give full regard to the social, economic, and cultural attributes of rural life, not just the environmental and landscape criteria (Gkartzios and Scott 2010; Scott and Murray 2009), but in the western country, academic discourse about the rural is usually produced by sociologists and geographers, with little interaction with disciplines outside the social science spectrum, such as architecture (Donovan, Gkartzios). In China collective land ownership belongs to farmers collective which makes it possible to revitalize the countryside by the construction of unified housing. Nowadays, unified housing has become a major rural development...
project led by the government. However, controversy never ceases over its feasibility. As is revealed by the study of Liang and Li (2014), although moving into the unified houses can improve the living environment of the rural people, it exerts a negative influence upon the psychological health of these villages and their social relationship; meanwhile, there is no significant correlation between living in the unified houses and the physical health of the rural people. By contrast, according to the study conducted by He et al. (2009), moving in the unified houses can improve the family income significantly and reduce the gap between the rich and the poor in rural community. Cai et al. (2020) observed that the establishment of unified housing can alleviate the social conflicts and reduce the pressure of urban renewal. Zhang et al. (2018) studied the individual initiatives of rural people to move into the unified houses. As their research indicated, the individual initiatives of rural people would be influenced by the following factors: policy benefit expectation, the quality of unified houses, and household incomes per capita; and among the three influence factors, household incomes per capita is the most influential; to be specific, the higher the household income is, the more willing the rural people are to move into the unified house. Li et al. (2016) studied the renovation and addition conducted by the rural people when they moved into the unified house. Most studies on unified houses focus on the aspects of policy and economy; in contrast, quite little has been done about the rural people’s preference for the style of unified houses. Accordingly, to better promote the development of unified houses in rural China, this study focuses on the rural people’s preference for the external form of unified houses and on this basis assess the design effect of the current unified houses.

1.2. Visual impact assessment

Iverson (1985) defined visual impact assessment as a method to describe the visual quality of a quantitative perspective. This method has been widely used in the constructions such as agro-industrial buildings (García, Hernández and Ayuga 2003), wind power plants (Szumilas-Kowalczyk, Pevzner and Giedych 2020), photovoltaic power plants (del Carmen Torres-Sibille et al. 2009), and high voltage lines (Palmer 2019). In addition, this method can also be used to assess the influence of different physical characteristics of buildings on the viewers’ visual impact assessment (Kaltenborn and Bjerke 2002).

Jennath and Nidhish (2016) studied students’ visual preference of the library building in Mahatma Gandhi University (located in Kottayam, Kerala) by means of visual impact assessment. As their study indicated, students’ visual impact assessment of the library building was positively related to the expected reading comfort; moreover, the color, texture, and geometrical shape of building also exerted certain influence on students’ visual impact assessment. Zhen et al. (2020) used visual impact assessment to study the detached houses in Jiangsu province, China. They found that architectural style, aspect ratio, window-wall ratio, and local environment are the main factors that influence people’s visual impact assessment; in addition, they also discovered that respondents with different demographic characteristics tend to assess the detached houses differently.

In terms of rural residence study, Frontuto et al. (2020) used visual impact assessment to explore the visual preference of residents who lived in Lange-Roero and Monferrato for the newly built small buildings in the rural area. They found that physical properties like color of the wall, color of the roof, vegetable barriers, and plant green walls exert certain influence upon the visual preference of the local residents; and among all the physical properties, plant green walls is the most influential. Evans (2019) studied the respondents’ visual preference for small buildings with the same method and found that the residents of South Carolina, America preferred the small wooden buildings with typical national characteristics or built in the traditional way.

1.3. The physical features of external form of buildings

The external form of buildings is constituted by different physical features which would exert direct influence on visual impact assessment, such as the height, form, and color of buildings (Norouzian-Maleki et al. 2018). To be specific, building height (Tara, Lawson and Renata 2021), the roof type (Heath, Smith, and Lim 2000), and the complexity of façades (Akalin et al. 2009) all influence the respondents’ visual impact assessment of buildings. Zarghami et al. (2019) observed that buildings whose aspect ratio were 4 or 5 were preferred to those whose aspect ratio were 3. According to the study of Dupont et al. (2017), the volume of buildings in the landscape exerts certain influence on the public’s visual impact assessment. Samavatekbatan, Gholami, and Karimimoshaver (2016) used computer software to alter the height, roof form, and color of the particular buildings to study the aesthetics of architectures. As their study reveals, the complexity of roof type is positively related to the public’s preference. Özdemir (2010) maintained that the complexity of façades is to a great extent related with windows. The capaciousness and transparency of windows is highly influential to people’s visual preference in that they prefer to enjoy the natural scenery through windows (Kearney and Winterbottom 2006).

Besides the above-mentioned physical features, considering the particularity of unified houses, the
greening in the courtyard and in front of the houses is also highly influential to the external form of unified houses. In the residential buildings, the courtyard is usually the main space where family members have their outdoor recreation; meanwhile, it can also serve as the space for production and guest-reception (Arnold and Lang 2007). The courtyard can also play an active role in improving the housing environment and even promoting the health of residents (O’Rourke and Nash 2019). van Heezik et al. (2013) discovered that cultural background, family income, and education are three demographic characteristics that influence the respondents’ visual preference for the courtyard. According to Van den Berg and van Winsum-Westra (2010), the is an important way of self-presentation for the residents living there whose size and style can reflect the family feature and background. Therefore, respondents with different demographic characteristics show various preferences for the greening style in front of the house. Larsen and Harlan (2006) observed that family income is highly influential to the residents’ preference for residential landscape. To be specific, low-income families prefer lush lawn whereas the high-income families prefer shrubs and bushes as the residential landscape of their house. To sum up, the residential landscape plays an important role in improving urban environment (Inkiläinen et al. 2013).

Based upon the previous studies, this research selected five physical features of buildings as research objects to study the external form of unified house. The five selected physical features are as follows: building stories, roof type, courtyard area, window-wall ratio, and residential landscape area.

### 1.4. Demographic characteristics

Yu (1995) maintained that people with different social backgrounds tend to differ in their preference for landscapes. Other studies also proved the existence of this difference, but held at the same time that this difference is insignificant (De Val and Mühlhauser 2014). Tveit (2009) argued that the demographic characteristics do exert certain influence upon people’s visual impact assessment. Due to the influence of cognitive motivation, different social backgrounds would also lead the respondents to different visual impact assessment (Daniel 2001; Sevenant and Antrop 2010; Webster and Kruglanski 1994). Wang and Zhao (2017) discovered that gender, age, and education level are three demographic characteristics which influence the respondents’ visual impact assessment of the same landscape. López-Martínez (2017) studied the influence of the three characteristics on visual impact assessment and found that females would usually assess an image comparatively lower than male do; and that age is positively related to the assessment value; whereas the respondents with higher education level would score the image lower than those with lower education level do. Of the demographic characteristics under study, cultural background (Molnarova et al. 2012), gender (Lindemann-Matthies, Junge, and Matthies 2010; Strumse 1996), age (Van den Berg and Koole 2006), professional knowledge (Vouligny, Domon, and Ruiz 2009), occupation (Svobodova et al. 2012), and living surroundings (Wendel, Zarger, and Mihelcic 2012) all exert certain impact on people’s visual assessment.

As far as family-related demographic characteristics are concerned, the householder is usually considered to be the respondent on behalf of his/her whole family (Charles, Hurst, and Roussanov 2009). This is because the householder is generally the main contributor to family income, and thus enjoy a greater say in family decision-making (Posel 2001). Ogden et al. (2018) observed that the education level of the householder is positively related with the health situation of the family members. Zhao et al. (2019) revealed that the householder’s demographic characteristics exert certain influence upon household energy conservation. However, some research countered that taking householder only into consideration may lead to inaccurate results in that the householder cannot represent the demand of the whole family (Kleinjans 2013).

In order to make the research results more instructive to the actual project development, this research set the householder of rural families as direct respondent and the family members as indirect respondents; meanwhile, the research model was also adjusted to instruct the householder and his/her family members to discuss together. Considering the overall demographic characteristics of families under study, this research selected four as the target characteristics to be studied. The four characteristics are as follows: the age of householders, family income per capita, family member composition, and the size of house.

### 1.5. Research questions

By means of questionnaire survey, this research collected the data on visual impact assessment of different unified houses from families participating in the investigation as well as the demographic characteristics of these families. Based on data analysis and further discussion, this research aimed to explore the following questions: How do different physical features influence rural families’ visual impact assessment of the external forms of unified houses? Is there any difference between families with different demographic characteristics in their visual impact assessment of unified houses? If the answer is positive, what is the difference then?
2. Research methodology

2.1. The layout of research program

The investigation was conducted in Jiangsu, Zhejiang, and Shandong provinces of China (as shown in Figure 1). Located in the east of China, three provinces have a huge economic scale; meanwhile, the living standard in these provinces is relatively high. Since many unified housing projects have been constructed in these provinces, it would be representative to conduct a research on China’s unified housing development in the three provinces.

In total, 42 unified housing projects were investigated. Through analyzing the investigation results and summarizing the previous studies, five physical features were selected as the research objects to study their influence on the external forms of unified houses. The five elements are building stories, roof type, courtyard area, window-wall ratio, and residential landscape area. By control variable method, the five elements are quantified as follows (see Table 1):

(1) Building stories: Building height has always been a key issue in the existing studies on visual impact assessment. Given that the storey height in unified housing projects is relatively consistent, the number of stories can be taken as one basic unit for the research. The unified houses under study were divided into two types: two-storey and three-storey. If the storey height was less than two meters, the storey would be excluded from the total number of building stories.

(2) Roof type: Two roof forms were selected which are the most commonly used forms in unified houses, namely, sloped roof, and composite roof (flat roof + sloped roof).

(3) Residential landscape area: As for the unified houses with residential landscapes, the average value of residential landscape area was calculated; then those whose residential landscape area was larger than the average value were defined as big while those whose residential landscape area was smaller than the average value were defined as small. Accordingly, in terms of residential landscape, the unified houses were divided into three types: without, small, and big.

(4) Courtyard area: As for the unified houses with a courtyard, the average value of courtyard area was calculated; then those whose courtyard area was larger than the average value were defined as big while those whose courtyard area was smaller than the average value were defined as small. Accordingly, in terms of courtyard, the unified houses were divided into three types: without, small, and big.

(5) Window-wall ratio: The window-wall ratio is expressed by the ratio between the window area and wall area. The relative area of windows in unified houses can be obtained by the following formula: \( a = S1/S2 \), where \( S1 \) refers to the window area and \( S2 \) denotes the façade area. Given that only the main façade can be seen from the seven pictures, the window-wall ratio of the main façade in each picture is calculated one by one and then the average value is calculated. Similarly, the ratio which is larger than the average value is defined as high and the ratio smaller than the average value is defined as low.

After the five physical features were determined and quantified, forty-two pictures of unified houses were sent to six experts of architecture who were asked to score the pictures according to the five variables. Then the average score of each picture was

| Table 1. The physical features of buildings. |
|---------------------------------------------|
| Building stories | Two-storey = 1; three-storey = 2 |
| Roof form | composite roof (flat roof + sloped roof) = 1; sloped roof = 2 |
| Residential landscape | without = 1; small = 2; big = 3 |
| Courtyard | without = 1; small = 2; big = 3 |
| Window-wall ratio | low = 1; medium = 2; high = 3 |

Figure 1. Study area.
calculated. The top seven pictures were selected to be further studied. As for the pictures taken by cameras, differences in shooting angle and brightness would be inevitable. To avoid the influence of these differences, the seven pictures selected were modeled by SketchUp2019 and rendered by VARY4.2 (Zhen et al. 2020). According to the Report on the status of Nutrition and Chronic Diseases among Chinese Residents released by the State Council of China in 2017, the average height of residents in the three provinces is 169 cm. Therefore, when rendering, the viewing angle is set at 165 cm up from the ground and the climatic background is unified to be sunny and bright. Finally, seven rendered pictures were obtained (as shown in Figure 2), and the corresponding physical features are listed in Table 2.

2.2. The demographic characteristics of families surveyed

This research selected rural families who have not moved into the unified houses as the survey subjects. And then the age of householder, family income per capita, family members, and the size of current residence were set as the variables. According to the data from the sixth national population census, these demographic characteristics were classified and shown in Table 3.

2.3. Questionnaire survey

The seven rendered pictures were printed on A4 full-color photo paper with 300 dpi, and then bound in a volume in random order. The questionnaire survey was conducted in Mazhuang village, Kunxi village, Xishanzi village and other twelve villages located in Jiangsu, Shandong, and Zhejiang provinces. One thing in common among all the fifteen villages is that there is no unified housing program ever developed. In China, many rural people work in cities or other places, so it is impossible to force all villagers to participate in the survey. Therefore, the survey can only involve the villagers we can find or see during the survey, so the

| Building stories | Roof form | Residential landscape | Courtyard | Window-wall ratio |
|------------------|-----------|-----------------------|-----------|-------------------|
| A Two-storey     | Composite roof | Big | Without | Medium |
| B Three-storey  | Sloped roof | Small | Small | High |
| C Three-storey  | Sloped roof | Whitout | Small | Low |
| D Three-storey  | Composite roof | Without | Big | High |
| E Two-storey    | Sloted roof | Without | Big | High |
| F Two-storey    | Composite roof | Big | Without | Low |
| G Three-storey  | Composite roof | Small | Small | Medium |

Table 2. The physical features of the seven pictures.

| Demographic characteristics | Variable |
|-----------------------------|----------|
| The size of current residence | Large (over 115㎡) |
|                             | Medium (95–115㎡) |
|                             | Small (smaller than 95㎡) |
| Age                         | 18–34 |
|                             | 35–59 |
|                             | ≥60 |
| Family income per capita    | High (over 13,200 yuan) |
|                             | Medium (10,800–13,200 yuan) |
|                             | Low (less than 10,800 yuan) |
| Family members              | Fewer than three |
|                             | Three members |
|                             | More than three |

Table 3. The demographic characteristics classification of families surveyed.

![Figure 2. Seven rendered pictures.](image)
families living in these villages were surveyed randomly about their willingness to move into the houses displayed in the seven pictures. At first, all the seven pictures were shown to the householders of the families surveyed; then the householder would discuss with other family members and score the pictures within the range of 1–7; meanwhile, they were asked to fill in the questionnaires so as to obtain their demographic characteristics.

The survey was conducted from September to November of 2019. In total 283 families were surveyed and 257 valid questionnaires were collected, with the rate of validity being 90.81%. The demographic characteristics of families surveyed are shown in Table 4. As the statistics reveals, the demographic characteristic distribution of these families is similar to that of the sixth national population census, which means the survey is highly representative.

The data collected were analyzed with SPSS 22.0 to explore the influence of different demographic characteristics on the respondents’ visual impact assessment of the five physical features, namely, building stories, roof form, courtyard size, window-wall ratio and residential landscape. On this basis, multi-variation linear regression analysis was conducted for further study.

3. Results

3.1. The overall assessment of the seven pictures

The intergroup reliability of the seven pictures representing different physical attributes was tested through SPSS 22.0 and the result was 0.751, displaying a relatively high internal reliability. Accordingly, it can be concluded that the questionnaire survey was reliable and the data collected can be competently used for further detailed analysis.

In the experiments where pictures are used to replace actual landscapes, the average score of pictures can be taken as the valid data on respondents’ visual impact assessment. The assessment produced by the respondents would vary in accordance with the content of the pictures (Samavatekbatan, Gholami, and Karimimoshaver 2016). The average score of each picture given by the respondents can be expressed by S. Of the seven pictures, the highest average score is 5.42 while the lowest 3.17. The average score of all the seven pictures is 4.24. The highest average score goes to Picture D and the lowest average score goes to Picture F.

3.2. The correlation between physical features and visual impact assessment

To study the relationship between the five physical features and visual impact assessment, multi-factor analysis of variance was conducted. The building stories (H), roof type (T), courtyard area (C), window-wall ratio (W), and residential landscape area (G) are taken as factors in the multi-factor analysis of variance; and the average score (S) of each picture is taken as the dependent variable. The analysis results are shown in Table 5.

As is indicated by the multi-factor analysis of variance, the model (F = 147.904, P = 0.001) is valid as a whole. Meanwhile, the model fit index (R²) is 0.504, indicating that the model is suitable for the data collected through questionnaire survey. Therefore, according to SPSS analysis, the null hypothesis is rejected that significant difference exists in at least one of the five factors (H, T, C, W, G). When the five factors are analyzed separately, the statistic results indicate that significant difference exists in all the five factors: H (F = 396.917, P = 0.000), T (F = 27.221, P = 0.009), C (F = 58.422, P = 0.000), W (F = 7.054, P = 0.012), G (F = 2.593, P = 0.035).

Consequently, it can be concluded from the multi-factor analysis of variance that when the average score is set as the dependent variable, significant difference exists in all the five physical features. In other words, the five physical features do influence the average scores of pictures; and among the five, building stories

| Table 4. The demographic characteristic statistics of families surveyed. |
|---------------------------------|------------------|
| Demographic characteristics     | Number of families surveyed | Proportion |
|---------------------------------|------------------|
| The size of current residence   | Large            | 89      | 34.63 |
| Age 18–34                       | Medium           | 106     | 41.25 |
| Average                        | Small            | 62      | 24.12 |
| Number of families              | 206              |         |      |
| Family income per capita        | High             | 34      | 13.23 |
| Low                            | Medium           | 183     | 71.21 |
| Number of family members        | Fewer than three | 63      | 24.51 |
| Number of family members        | Three            | 90      | 35.02 |
| Number of family members        | More than three  | 104     | 40.47 |

| Table 5. Multi-factor analysis of variance on subject effect. |
|---------------------------------|------------------|
| Source                          | Ill type quadratic sum | Degree of freedom | Mean square | F         | Significance |
| Correction model                | 34.129*          | 17               | 3.281       | 147.904   | .001        |
| Intercept                      | 3748.107         | 1                | 3837.193    | 224293.895| .000        |
| H                               | 22.651           | 5                | 7.117       | 396.917   | .000        |
| T                               | 3.183            | 6                | 1.442       | 27.221    | .009        |
| C                               | 5.312            | 4                | 1.041       | 58.422    | .000        |
| W                               | 7.683            | 6                | 1.054       | 7.054     | .012        |
| G                               | 4.983            | 5                | 0.942       | 2.593     | .035        |
| Error                           | 3.138            | 393              | 6.023       |           |             |
| Total                           | 2066.329         | 385              |             |           |             |
| Total after correction          | 41.074           | 374              |             |           |             |

*R square = .681 (after correction, R square = .504).*
and courtyard size are more influential to respondents’ visual impact assessment.

### 3.3. The correlation between demographic characteristics and visual impact assessment

One-way analysis of variance was conducted and the results indicate that significant difference exists between the age of householder (F = 7.215, p = 0.042), family income per capita (F = 7.215, p = 0.042), family members (F = 7.215, p = 0.042) and the scores given by the families surveyed. Meanwhile, no significant difference exists between the size of current residence (F = 1.554, p = 0.190) and the scores given by the families surveyed. Through correlation coefficient for ranked data analysis, the correlation between demographic characteristics and visual impact assessment is tested, which shows significant correlation between the average score (S) and the age of householder, family income per capita, and family members. The results are shown in Table 6.

The data collected is further analyzed through stepwise linear multi-variation regression model. In this model, the age of householder, family income per capita, family members, and the size of current residence are taken as independent variables and the average score of pictures (S) is set as dependent variable (as shown in Table 7). As the results show, the age of householder, family income per capita, and family members exert significant influence on the average score of pictures; by contrast, the size of current residence is far less influential to visual impact assessment. Accordingly, the size of current residence is excluded out of the model. Meanwhile, as can be seen from the multi-variation regression model that there is no interaction among the age of householder, family income and family members.

#### Table 6. Correlation coefficient for ranked data analysis.

| Income         | Score | Income | Age | Family members |
|----------------|-------|--------|-----|----------------|
| Coefficients   | −0.22 | 0.000  | 0.59| 0.061          |
| Significance   | 0.000 | 0.000  | 0.000| 0.000          |

#### Table 7. Stepwise linear multi-variation regression analysis.

| Unstandardized coefficients | Standardized coefficients | Collinearity statistics |
|-----------------------------|---------------------------|-------------------------|
| B                           | Beta                      | t           | Sig. | Tolerance | VIF |
| (Constant)                  | 3.826                     | 15.962      | 0.000| 0.896     | 1.369|
| The age of householder      | 0.392                     | 0.852       | 4.992| 0.021     | 0.482|
| Family income per capita    | −0.492                    | −1.489      | −7.167| 0.000     | 3.556|
| Family members              | −0.538                    | −0.457      | −3.609| 0.017     | 0.386|

### 3.4. The respondents’ demographic differences and the pictures’ physical features

The average score of each picture given by families of different demographic characteristics is set as dependent variable; the five physical features are set as independent variables. As is shown in the stepwise linear multi-variation regression model, the difference in householder’s age, family income, and family members would lead to different significant predictors (as shown in Table 8).

For the families whose householders are under the age of 40, building stories (H) and courtyard area (C) are reliable predictors for visual impact assessment; for families whose householders aging from 41 to 60, residential landscape (G), courtyard area (C), and window-wall ratio (W) are reliable predictors; for families whose householders are over 60 years old, building stories (H), roof type (T), and residential landscape (G) are reliable predictors.

For families whose income is relatively low, roof type (T), residential landscape (G), and courtyard area (C) are reliable predictors; for families with medium income, building stories (H) and courtyard area (C) are reliable predictors for visual impact assessment; for families with high income, building stories (H), roof type (T), courtyard area (C), and residential landscape (G) are reliable predictors for visual impact assessment.

For families whose members are fewer than three, residential landscape (G), courtyard area (C), and window-wall ratio (W) are reliable predictors; for families of three members, building stories (H) and window-wall ratio (W) are reliable predictors; for families with more than three members, building stories (H), roof type (T), and courtyard area (C) are reliable predictors for visual impact assessment.

K-S was used to test whether there exists any collinearity between the models. As the calculation results show, the residual errors are normally distributed, which indicates that there is no collinearity in these models.

### 4. Discussion

#### 4.1. The influence of different physical features on visual impact assessment

#### 4.1.1. Building stories

Building stories do exert certain influence upon the rural families’ visual impact assessment. To be specific, they score the three-storey houses higher than the
two-storey ones. This may be justified by the fact that the plane size of single floor in unified houses is similar and the three-storey houses would appear to be more slender, thus catering to the public’s aesthetic taste. Besides, the residents usually prefer larger living space so that they would score the three-storey houses higher than the two-storey ones. This is contrary to the conclusion drawn by from their study that rural people prefer lower residence. Probably this is because that study was conducted in Europe and the respondents have different visual preferences due to the difference in cultural and geological backgrounds.

4.1.2. Roof type

Roof type also exerts certain influence on rural families’ visual impact assessment. The composite roof (flat + sloped roof) is scored higher than the sloped roof in that the combination of flat roof and sloped roof provides a better view to the respondents. In addition, alteration and addition are quite common in rural residence. In this case, the flat roof can better satisfy the demand of rural people. The flat roof also has some practical uses such as drying grain in the sun. Therefore, the composite roof is more popular among the rural people. Li et al. (2016) also drew the same conclusion from their study.

4.1.3. Residential landscape area

Residential landscape area is also influential to rural families’ visual impact assessment. The house with small residential landscape is scored the highest whereas the house without greening is scored the lowest. Residential landscape belongs to public space upon which rural people have relatively low demand. Accordingly, the houses with small area of greening are scored higher. Comparatively speaking, the rural people attach more importance to private space. What is more, greening in front of the house can also improve the overall beauty of the house and reflect the income level of the family (Nassauer et al. 2014).

4.1.4. Courtyard area

The area of courtyard also influences the rural families’ visual impact assessment. To be specific, the unified house with large courtyard is scored the highest while the house without a courtyard is scored the lowest. Generally speaking, rural residents are accustomed to raising some small fowls or conducting some auxiliary production activities like storage or drying grains in the yard. Therefore, they do need as large a courtyard as possible. This conclusion is similar to what was drawn from the study conducted by Ossola et al. (2019).
4.1.5. **Window-wall ratio**

Window-wall ratio exerts certain influence on visual impact assessment. Similar to the conclusion drawn by Zhen et al. (2020), the conclusion drawn in this research goes as follows: the house with medium window-wall ratio is scored the highest whereas the house with low ratio is scored the lowest. The reason for this could be that the climate of the region where the survey was conducted is hot in summer and cold in winter. Accordingly, large windows are detrimental to indoor insulation, but small windows make the room gloomy. In this sense, houses with medium window-wall ratio are more popular among the rural people.

4.2. **The influence of the families’ demographic characteristics on visual impact assessment**

Howley, Donoghue, and Hynes (2012) maintained that people with different demographic characteristics would produce different visual impact assessment and that this difference was the result of multiple factors like the living environment and experiences of the respondents. This research also drew some similar conclusions.

4.2.1. **The age of householder**

The age difference would lead to different visual impact assessment of the external form of unified houses. As is indicated by this research, the average scores of pictures are positively related with the age of householders. In other words, the older the householders are, the higher they would score the pictures. This is in line with the study conducted by López-Martínez in 2017. The main reason for this result is that compared with the newly constructed unified houses, their past or current living environment is relatively poor so that they would think the unified houses are more advanced and comfortable. By contrast, the young householders usually have more knowledge about high-quality living environment thanks to their working experiences in big cities or nerturfing experience. In this case, they would have higher expectation upon their living environment, thus scoring the pictures lower than the elder householders do.

4.2.2. **Family income per capita**

The difference in family income per capita also exerts certain influence upon the rural families surveyed to produce different visual impact assessment. As this research reveals, families with high income would produce the lowest visual impact assessment of the unified houses; whereas the families with medium income score the unified houses highest. This can be justified by the fact that families with high income are more likely to afford a higher living standard than what the unified house can offer. In this case, they would prefer more individual design, thus producing relatively lower visual impact assessment of the unified house. On the other hand, families with medium income assess the unified house much higher than the families with low income do. This may be due to the fact that families with medium income are usually more positive towards new living environment and life pattern.

4.2.3. **Family members**

The number of family members is also influential for rural families to produce different visual impact assessment of the unified house. As is illustrated in this research, families with three members produce the highest visual impact assessment of the unified house whereas families with more than three members render the lowest assessment. Usually, a family of three members is composed of two parents and one child. This kind of family would be more longing for the better auxiliary service facilities. During the questionnaire survey, it was found that families with more than three members have more requirements upon their future residence which the unified house cannot satisfy. Consequently, these families would hold a relatively negative attitude towards unified houses.

4.3. **The correlation between demographic characteristics and physical features**

4.3.1. **The age of householder and physical features**

As for the families whose householders are under the age of 40, they attach more importance to building stories and courtyard area. These families prefer three-storey houses with a large courtyard; the courtyard area is the largest influence factor to their visual impact assessment in that these families are more productive and thus need more outdoor space for agricultural production. As for the families whose householders are between the age of 40 and 60, they attach more importance to residential landscape area, window-wall ratio, and courtyard area. The householders of these families prefer houses with a larger area of residential landscape, small courtyard, and large window-wall ratio. Among the three physical features, window-wall ratio is the most influential, which can be justified by the fact that the climate in this region is relatively mild and the family members spend more time in their houses. In this case, a bright, warm indoor environment would be their priority. As for the families whose householders are over the age of 60, they attach more importance to building stories, roof type and residential landscape area. The householders of these families prefer two-storey houses with sloped roof, and small residential landscapes. Of the three elements, residential landscape area is the most influential to the families’ visual impact assessment. These families pay more attention to the overall charm of the house; small area of residential landscapes is more in line with their
aesthetic pursuit. Meanwhile, they also score the two-storey houses higher than the three-storey ones in that their mobility declines as they grow older and older. In this case, lower houses would be more desirable to these families.

4.3.2. Family income per capita and physical features
Families with low income attach more importance to residential landscape area, roof type, and courtyard area. This type of families prefer large residential landscape, sloped roof, and large courtyard. Among the three physical features, courtyard area is the most influential to their visual impact assessment because they would use the courtyard to raise domestic fowls or plant some vegetables to save money. Consequently, they prefer large courtyards. Meanwhile, this type of families also render the highest score upon large residential landscapes because they rely more on public environment due to their limited economic conditions. Families with medium income attach more importance to building stories and courtyard area. To be specific, they prefer three-storey houses with small courtyards. Of the two physical features, building stories is more influential. This type of families have higher demand upon their living space and greater initiative to improve their life quality. Large and spacious living environment can satisfy their demand in this aspect. Families with high-income pay more attention to building stories, roof type, courtyard area, and residential landscape area. These families prefer three-storey houses with composite roof, small area of residential landscapes, and large courtyard. And among the four physical features, courtyard area exerts the largest influence upon their visual impact assessment. To these families, besides the agricultural use, courtyard can also serve as the space for entertaining guests and family gathering. Meanwhile, they also render the highest score upon small residential landscapes in that they may think delicate residential landscape can reflect their artistic taste.

4.3.3. Family members and physical features
Families with fewer than three members attach more importance to residential landscape area, window-wall ratio, and courtyard area. This type of families prefer houses with small residential landscape, medium window-wall ratio and without courtyard. Among the three physical features, courtyard area is the most influential to their visual impact assessment. As is revealed by the survey, the life of these families is relatively monotonous so that they long for communicating with their neighbors. Without courtyards, the residents can exchange more freely. Families with three members pay more attention to building stories and window-wall ratio. This type of families prefer three-storey houses with large window-wall ratio. Of the two physical features, window-wall ratio exerts greater influence upon their visual impact assessment. Most likely, there is usually an underage child in a family of three people. The parents would like to have more sunlight which would be advantageous to the healthy growth of the child. As for families with more than three members, building stories, roof type, and courtyard area are the three influence factors for their visual impact assessment. This type of families prefer three-storey houses with composite roof and large courtyard. Among the three physical features, building stories is the most influential. Meanwhile, this type of families also render the highest score upon the composite roof (flat roof +sloped roof). During the survey, many families of this type mentioned that flat roof would be more favorable for the addition of the unified houses. Hence, it can be concluded that this type of families have higher demand upon the residence area, which also justifies their preference over three-storey houses.

4.4. Limitations and prospects
This research discussed the difference in rural families’ visual impact assessment of unified houses. However, China is a vast country, and the research sites are concentrated in the Central Plains. Families with different regional cultural backgrounds and the subsequent policies of the government on rural families which have moved into the unified housing may have an impact on the villagers’ evaluation of the unified housing. These problems are worthy of further study.

5. Conclusion
This research studied the correlation between the physical features of unified houses and rural residents’ visual impact assessment. As is revealed by the research, building stories, roof type, courtyard area, window-wall ratio, and residential landscapes all influence rural residents’ visual impact assessment of the external form. Among the five elements, building stories and courtyard area are comparatively more influential whereas window-wall ratio is less influential.

The housing programs which can satisfy the demand of majorities are more likely to win the public’s support. On the contrary, the housing programs which ignore the demands of different groups of owners would probably end up with failure (Gobster et al. 2007; Zhen et al. 2020). One basic task for architects is to get full knowledge about the demands of the target groups and architectural design which can better meet their expectations. It is of vital importance to explore the demands of the target people. This research provides references for the designers of unified houses to reduce the level of discontent among the unified house owners and improve the quality of unified
housing projects.

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References

Akalin, A., K. Yildirim, C. Wilson, and O. Kilicoglu. 2009. “Architectural Engineering Students’ Evaluations of House Façades: Preference, Complexity and Impressiveness.” Journal of Environmental Psychology 29 (1): 124–132. doi:10.1016/j.jenvp.2008.05.005.

Arnold, J. E., and U. A. Lang. 2007. “Changing American Home Life: Trends in Domestic Leisure and Storage among Middle-class Families.” Journal of Family and Economic Issues 28 (1): 23–48. doi:10.1007/s10834-006-9052-5.

Cai, Y., Xie, J., & Tian, C. (2020). Housing wealth change and disparity of indigenous villagers during urban village redevelopment: A comparative analysis of two resettled residential neighborhoods in Wuhan. Habitat International 99: 102162. doi:10.1016/j.habitatint.2020.102162

Charles, K. K., E. Hurst, and N. Roussanov. 2009. “Conspicuous Consumption and Race.” The Quarterly Journal of Economics 124 (2): 425–467. doi:10.1162/qjec.2009.124.2.425.

Daniel, T. C. 2001. “Whither Scenic Beauty? Visual Landscape Quality Assessment in the 21st Century.” Landscape and Urban Planning 54 (1): 267–281. doi:10.1016/S0169-2046(01)00141-4.

De Val, G. D. L. F., and H. Mühlhäuser. 2014. “Visual Quality: An Examination of a South American Mediterranean Landscape, Andean Foothills East of Santiago (Chile).” Urban Forestry & Urban Greening 13 (2): 261–271. doi:10.1016/j.ufug.2014.01.006.

del Carmen Torres-Sibille, A., Cloquell-Ballester, V.-A., Cloquell-Ballester, V.-A., and Ramirez, M. A. (2009). Aesthetic impact assessment of solar power plants: An objective and a subjective approach. Renewable and Sustainable Energy Reviews,13(5), 986–999. doi:10.1016/j.rser.2008.03.012

Deng, Y., Qi, W., Fu, B., and Wang, K. (2020). Geographical transformations of urban sprawl: Exploring the spatial heterogeneity across cities in China 1992–2015. Cities, 105, 102415. doi:10.1016/j.cities.2019.102415

Dupont, L., Ooms, K., Antrop, M., and Van Eetvelde, V. (2017). Testing the validity of a saliency-based method for visual assessment of constructions in the landscape. Landscape and urban planning, 167, 325–338.doi:10.1016/j.landurbplan.2017.07.005

Evans, K. (2019). Exploring the relationship between visual preferences for tiny and small houses and land use policy in the southeastern United States. Land Use Policy, 81, 209–218. doi:10.1016/j.landusepol.2018.10.051

Frontuto, V., A. Corsi, S. Novelli, P. Gullino, and F. Larcher. 2020. “The Visual Impact of Agricultural Sheds on Rural Landscapes: The Willingness to Pay for Mitigation Solutions and Treatment Effects.” Land Use Policy 91: 104337. doi:10.1016/j.landusepol.2019.104337.

Garcia, L., Hernández, J., and Ayuga, F. (2003). Analysis of the exterior colour of agroindustrial buildings: a computer aided approach to landscape integration. Journal of environmental management, 69(1), 93–104. doi:10.1016/S0301-4797(03)00121-X

Gkartzios, M., and S. Scott. 2010. “Residential Mobilities and House Building in Rural Ireland: Evidence from Three Case Studies.” Sociologia Rurals 50 (1): 64–84. doi:10.1111/j.1467-9523.2009.00502.x.

Gobster, P. H., J. I. Nassauer, T. C. Daniel, and G. Fry. 2007. “The Shared Landscape: What Does Aesthetics Have to Do with Ecology?” Landscape Ecology 22 (7): 959–972. doi:10.1007/s10160-007-9010-x.

He, S., Y. Liu, C. Webster, and F. Wu. 2009. “Property Rights Redistribution, Entitlement Failure and the Impoverishment of Landless Farmers in China.” Urban Studies 46 (9): 1925–1949. doi:10.1177/0042098009106015

Heath, T., S. G. Smith, and B. Lim. 2000. “Tall Buildings and the Urban Skyline: The Effect of Visual Complexity on Preferences.” Environment and Behavior 32 (4): 541–556. doi:10.1177/00139160021972658.

Howley, P., C. O. Donoghue, and S. Hynes. 2012. “Exploring Public Preferences for Traditional Farming Landscapes.” Landscape and Urban Planning 104 (1): 66–74. doi:10.1016/j.landurbplan.2011.09.006.

Huang, T. 2019. Study on Elasticity Design Strategy of Collective New Countryside in North Guangdong, South China University of Technology. doi:10.27151/d.cnki.ghnl.2019.00348

Inkläinen, E. N. M., M. R. McHale, G. B. Blank, A. L. James, and E. Nikinmaa. 2013. ”The Role of the Residential Urban Forest in Regulating Throughfall: A Case Study in Raleigh, North Carolina, USA.” Landscape and Urban
van Heezik, Y., C. Freeman, S. Porter, and K. J. M. Dickinson. 2013. “Garden Size, Householder Knowledge, and Socio-economic Status Influence Plant and Bird Diversity at the Scale of Individual Gardens.” *Ecosystems* 16 (8): 1442–1454. doi:10.1007/s10021-013-9694-8.
Vouiligny, É., G. Domon, and J. Ruiz. 2009. “An Assessment of Ordinary Landscapes by an Expert and by Its Residents: Landscape Values in Areas of Intensive Agricultural Use.” *Land Use Policy* 26 (4): 890–900. doi:10.1016/j.landusepol.2008.10.016.
Wang, H., L. Wang, F. Su, and R. Tao. 2012a. “Rural Residential Properties in China: Land Use Patterns, Efficiency and Prospects for Reform.” *Habitat International* 36 (2): 201–209. doi:10.1016/j.habitatint.2011.06.004.
Wang, J., Y. Chen, X. Shao, Y. Zhang, and Y. Cao. 2012b. “Land-use Changes and Policy Dimension Driving Forces in China: Present, Trend and Future.” *Land Use Policy* 29 (4): 737–749. doi:10.1016/j.landusepol.2011.11.010.
Wang, R., and J. Zhao. 2017. “Demographic Groups’ Differences in Visual Preference for Vegetated Landscapes in Urban Green Space.” *Sustainable Cities and Society* 28: 350–357. doi:10.1016/j.scs.2016.10.010.
Webster, D. M., and A. W. Kruglanski. 1994. “Individual Differences in Need for Cognitive Closure.” *Journal of Personality and Social Psychology* 67 (6): 1049. doi:10.1037/0022-3514.67.6.1049.
Wendel, H. E. W., R. K. Zarger, and J. R. Mihelcic. 2012. “Accessibility and Usability: Green Space Preferences, Perceptions, and Barriers in a Rapidly Urbanizing City in Latin America.” *Landscape and Urban Planning* 107 (3): 272–282. doi:10.1016/j.landurbplan.2012.06.003.
Yu, K. (1995). Cultural variations in landscape preference: comparisons among Chinese sub-groups and Western design experts. *Landscape and urban planning*, 32(2), 107–126. doi:10.1016/1060-1599(94)00188-9
Zarghami, E., M. Karimimoshaver, A. Ghanbaran, and P. SaadatiVaghar. 2019. “Assessing the Oppressive Impact of the Form of Tall Buildings on Citizens: Height, Width, and Height-to-width Ratio.” *Environmental Impact Assessment Review* 79: 106287. doi:10.1016/j.eiar.2019.106287.
Zhang, Z., Y. Wen, R. Wang, and W. Han. 2018. “Factors Influencing Rural Households’ Willingness of Centralized Residence: Comparing Pure and Nonpure Farming Areas in China.” *Habitat International* 73: 25–33. doi:10.1016/j.habitatint.2018.01.003.
Zhao, X., H. Cheng, H. Zhao, L. Jiang, and B. Xue. 2019. “Survey on the Households’ Energy-saving Behaviors and Influencing Factors in the Rural Loess Hilly Region of China.” *Journal of Cleaner Production* 230: 547–556. doi:10.1016/j.jclepro.2019.04.385.
Zhen, Z., M. Ma, Z. Shao, C. Han, and X. Bu. 2020. “A Study of Demographic Difference in External Visual Preference Evaluation of Chinese Detached House.” *Journal of Asian Architecture and Building Engineering* 19 (2): 151–165. doi:10.1080/13467581.2020.1723596.