Research on the correlation between the characteristics of bottom-level interface of commercial complex and the pedestrian behavior around: based on environmental behavior quantification technology

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ABSTRACT
This paper takes 30 commercial complexes in Wuhan, China as examples, based on literature, open data, observation experiment, environmental behavior research methods and environmental behavior quantification methods, SPSS software was used to analyze the correlation between the characteristics of the bottom-level interface of commercial complex and the pedestrian behavior around, the results show that the attractiveness of commercial complexes to surrounding pedestrians is strongly positively correlated with average transparency of bottom-level interface of commercial complex, and the intimacy degree of pedestrians around commercial complexes to commercial complexes is positively correlated with an average saturation of the color of the bottom-level interface of commercial complex. This means that through empirical research on various design factors of the commercial complex itself, explore the impact of the bottom-level interface of the commercial complex on the quality of urban space, and provide a data foundation and provides clues and experience, for planning and designing the high-quality bottom-level interface of commercial complex.

KEYWORDS
Commercial complex; bottom-level interface; pedestrian behavior; quantification; correlation

1. Introduction

1.1. Research background

With the accelerated pace of urbanization, a large number of commercial complexes have been built in cities of China under the rapid economic development and urbanization, which has a significant impact on urban open space. The open space around the commercial complex has gradually developed into an essential carrier of social life.

Open space in commercial district includes not only the open space inside the building but also the external space used by citizens’ interaction activities, this research focus on the impact of commercial complexes on the pedestrian behavior in the space outside the building entity, not including the space inside the building. In high-density districts, along the urban expressways, the main and secondary roads, although the layout of commercial complexes has certain rationality, bottom-level interface of the commercial complex is more or less unfriendly to pedestrians in the urban space environment.

Therefore, how to create a pedestrian-friendly bottom-level interface to commercial complex in an urban space has become an important issue in the design of the surrounding environment of commercial complex. It is believed that there are still some space interface factors of the building itself which will affect the behavior of the pedestrian in the open space of commercial complex.

1.2. Research purpose

The complexity of the commercial complex itself causes many design factors to affect the pedestrian behavior in its open space. However, this part has not been fully quantified. Therefore, it is hoped that this research can fill the gaps in the current research and provide a reference for the design of bottom-level interfaces of commercial complexes. Through the correlation test of the characteristics of the bottom-level interface of commercial complex and the pedestrian behavior around, the influence relationship is revealed, and finally, the planning suggestions of high-quality commercial complexes are proposed. The purpose of the research can be summarized in the following three points:

(I) Quantify the various characteristics of the bottom-level interface of commercial complex facing the open space and the pedestrian behavior in the open space around the bottom-level of a commercial complex.

(II) Analyze and clarify the correlation between the characteristics of the bottom-level interface of commercial complex and the pedestrian behavior around.
(III) Explore the impact of the bottom-level interface of the commercial complex on the quality of urban space, and provide a data foundation and design basis for future research and design practices of a better urban interface.

1.3. Research significance

Enough research samples and diverse population composition are critical to the accuracy of the experimental data. Wuhan, a megacity in the middle and lower reaches of the Yangtze River in central China, has grown rapidly in recent years. Wuhan is a city developed by commercial and trade activities. It is one of the earliest commercial port cities in China. Wuhan is also one of the fastest-growing cities in China in the recent past. In the latest round of global ranking, Wuhan’s economy ranked eighth in Chinese cities (Global Urban Competitiveness Report 2019–2020).

There are about 100 researchable objects in commercial complexes and more than 11 million people in Wuhan. However, there are still some shortcomings in the research of the relationship between urban space environment and bottom-level interface of commercial complex in Wuhan. So the author chose Wuhan for research. As the size of the city reaches the scale of the megacity, the social problems of the open space environment around the commercial complex are prominent, and creating a pedestrian-friendly bottom-level interface to commercial complex in an urban space has become an important issue in the design of the surrounding spatial environment of commercial complex.

2. Previous study

2.1. Quality of commercial open space

There are many definitions of open space quality. Open space has a compact on the economic value, the physical and mental health, and social dimension. In 2014, Vikas Mehta, an American scholar, defined sociality as the primary function of open space, and divided the quality of open space into four dimensions, including meaningfulness, safety, comfort, and pleasurability (Mehta 2014). The open space around the commercial complex not only guides the flow of people but also provides people with a pleasant experience. Therefore, good commercial bodies should attract the pedestrian traffic flow in the surrounding open space and promote the retention of them. Based on an extensive review of the literature and empirical work, this research creates the influencing factors to assess the influence of commercial complex on surrounding pedestrian behavior.

2.2. Previous research on the quality of public open space

In recent years, many scholars have had reviews on the urban public open space from different aspects, such as studies on protecting policies, attitudes towards policies and lessons from the urban public open space (Broussard, Washington-Ottombre, and Miller 2008; Bengston, Fletcher, and Nelson 2004; Sanders 2003); analysis on the specific situation in a certain area and studies on the satisfaction of different requirements of different groups (Turel, Yigit, and Ipek 2007; Yang and Kang 2005; Wu and Plantinga 2003; Suite 1985) and specific functions of the urban public open space (Backlund et al. 2004; Tang and Wong 2008). At present, it is rare to study the effect of commercial open space quality on pedestrian by quantitative means.

2.3. Previous research on variables affecting crowd behavior

In various studies on the influence of street space and interface on crowd activities, some scholars have examined different environmental variables. Jan Gehl pointed out the direct connection between the architectural factors of the interface and the spatial vitality, including the number of shops per 100 meters on the commercial street, the transparency of the boundary, the street unit, etc. The building interface is divided into five behavior levels (Gehl Architects 2006). Furthermore, the Space Syntax Co. analyzed the 17 walking environment factors in the city of London and found that the behavior level of the bottom-level interface is a key factor affecting street pedestrian traffic (De Arruda Campos et al. 2003). Chen Yong and Zhao Xinghua studied the ground floor interface of 17 sections of Huaihai Road in Shanghai and analyzed the influence of the width, transparency, store density and functional density of the street area on street activities (Yong and Zhao 2014).

Xu Leiqing and Kang Qi studied the relationship between pedestrian behaviors and the spatial features along the ground-floor commercial street; they used several building interface variables such as store density, function density and average transparency in their study, and proved that these interface characteristics do have a significant effect on the staying activity of pedestrians (Xu and Kang 2014). He Hui, Chen Yi and Lin Xiaowu studied on the identification and evaluation of influential factors of commercial street public space quality based on open data, the transparency they adopted refers to the ratio of the total length of open facades, transparent doors and windows to the total building base length, which has also proven to be very simple but effective (Hui, Yi, and Xiaowu 2018).
However, in addition to the factors revealed in the above empirical research literature, there are other spatial interface factors that also affect pedestrian activities outside the commercial complex. Does the design factor of the bottom-level interface of commercial complex itself, like the saturation of the material, the brightness, etc., affect the psychology of the pedestrian and their business behavior? Whether the hole coefficient and functional density of the ground floor store of the commercial complex will affect the people entering the building and promote the shopping behavior? The above factors have not been carried out in the current empirical research on commercial complexes.

3. Process of data collection

3.1. Selection of research subjects

There are about 100 researchable objects of commercial complexes in Wuhan. Because the image of large-scale commercial design often corresponds to the spatial scale of sparsely populated suburban streets, commercial establishments in densely populated urban areas may have problems such as insufficient friendliness and insufficient attractiveness of the bottom-level interface. In order to improve the quality of the bottom-level interface of commercial entities to the street public space in densely populated areas of the city, and to create a vibrant image of urban space, 30 commercial complexes were taken as the research object. The author selected 30 walk-based commercial complexes in the urban area for experiments; these commercial complexes have both large urban bottom-level interfaces and located in densely populated areas. In order to ensure the accuracy of the experimental data, the author selected these commercial complexes for three reasons:

(I) These 30 commercial complexes are all adjacent to the main road, some of which are also adjacent to the secondary road, ensuring that the selected commercial complexes are located in the urban area, not in the suburbs, which is in line with our research theme.

(II) These 30 commercial complexes are all located in blocks with a population density of 10,000 people/km² or higher in order to ensure a sufficient sample of pedestrians.

(III) These 30 commercial complexes are all with a building area of over 8,000 square meters, bottom interface length exceeds 300 meters and the number of floors in the podium section is between 3 and 10, ensuring that the selected commercial complexes are of the same type.

Details of 30 commercial complexes are shown in Table 1.

The distribution of 30 commercial complexes is shown in Figure 1.

3.2. Strategy for data collection

Many factors are influencing the open space of a commercial complex, in order to reduce the impact of non-research factors, the author screened 30 commercial complexes that met certain conditions, including traffic conditions, population density in the sub-district, length of the bottom interface, and convenience of transportation.

In the process of investigation, the conditions of climate and the subjective factors of the investigators were controlled, and the non-spatial interface elements of each sample were assimilated as much as possible. Also, the behavior variables in the survey were not evaluated with absolute data but transformed into relative proportion, thus weakening the influence of public transportation population composition and different business forms in each open space.

3.3. Collection of data in the field

Since the pedestrian’s behavior status has the dual characteristics of weekdays and weekends, several sunny Fridays in April, May and June 2018 were selected for investigation.

The behavior data are recorded by means of field observation, photographing, and video recording. Continuous five scan recordings were taken at 16:00–18:00 (half an hour). The survey data were organized according to different commercial complexes and time periods, and the pedestrian’s activities were calculated by using the laws of perspective through some known-size objects and analyzed. The average of the five data of each complex was used as the research data of the complex, which can reduce the impact of the accidental factors of a single survey. Finally, the data were converted into corresponding behavior variable indicators for unified measurement.

Commercial complex open spaces were measured by taking the photos of elevation and site plan (Figure 2), and the required interface length data are measured in the field.

4. The technology of spatial environmental behavior quantification

4.1. Selection and measurement of environment variables

Xu Leiqing and Kang Qi studied the relationship between pedestrian behaviors and the spatial features along the ground-floor commercial street, they used
several building interface variables such as store density, function density and average transparency in their study, and proved that these interface characteristics do have a significant effect on the staying activity of pedestrians (Xu and Kang 2014). In view of the fact that this research is a study of related design elements in the design of the bottom-level interface of a friendly city commercial complex in the future, we divides the environment variables that may affect pedestrian behavior in open space into two categories on the basis of integrating multiple literature sources:

(I) Interior elements, including store density, function density and hole coefficient.

(II) The material atmosphere factor of the complex, including average transparency, average brightness, and average saturation.

### 4.1.1. Store density, function density and hole coefficient

Store density in this research is defined as the number of storefronts in the unit length adjacent to the

| Number | Name of commercial complex | Number of floors above ground | Number of underground buildings | Bottom interface length (m) | District | Sub-district | Population density of the sub-district to which it belongs (person/km²) | Whether along the main road (Y = Yes; N = No) | Whether along the secondary road (Y = Yes; N = No) |
|--------|-----------------------------|-------------------------------|-------------------------------|--------------------------|---------|-------------|-------------------------------------------------|--------------------------------------------|---------------------------------------------|
| 1      | Aoshan Century Square       | 4                             | 2                             | 790                      | Qinghan District         | Hongwei Road | 12738.35                                        | Y                                           | Y                                           |
| 2      | Shopping Mall               | 4                             | 2                             | 550                      | Wuchang District         | Xujiapeng Road | 10850.23                                       | Y                                           | Y                                           |
| 3      | New World                  | 4                             | 1                             | 420                      | Hongshan District        | Liyuan Road   | 14627.66                                       | Y                                           | Y                                           |
| 4      | City of Stars               | 5                             | 3                             | 505                      | Wuchang District         | Xujiapeng Road | 10850.23                                       | Y                                           | Y                                           |
| 5      | Wanda Plaza (Chu Milky Street) | 5                         | 3                             | 630                      | Wuchang District         | Zhongnan Road  | 17173.91                                       | Y                                           | Y                                           |
| 6      | KaiDe 1818 Center           | 6                             | 3                             | 565                      | Wuchang District         | Zhongnan Road  | 17173.91                                       | Y                                           | N                                           |
| 7      | Zhongnan Tianzi Square      | 3                             | 2                             | 540                      | Wuchang District         | Zhongnan Road  | 17173.91                                       | Y                                           | N                                           |
| 8      | Zhongshang Square           | 4                             | 2                             | 580                      | Wuchang District         | Zhongnan Road  | 17173.91                                       | Y                                           | N                                           |
| 9      | YinTai Department Store     | 5                             | 2                             | 470                      | Wuchang District         | Zhongnan Road  | 17173.91                                       | Y                                           | N                                           |
| 10     | Langhu 68                   | 4                             | 2                             | 305                      | Wuchang District         | Zhongnan Road  | 17173.91                                       | Y                                           | N                                           |
| 11     | Wushang Trade Center        | 4                             | 2                             | 530                      | Hongshan District        | Zhongnan Road  | 17948.72                                       | Y                                           | Y                                           |
| 12     | New World Department Store  | 4                             | 2                             | 625                      | Hongshan District        | Luonan Road    | 17948.72                                       | Y                                           | Y                                           |
| 13     | YinTai Creative Center      | 10                            | 2                             | 455                      | Hongshan District        | Luonan Road    | 17948.72                                       | Y                                           | N                                           |
| 14     | Lotte City                  | 5                             | 3                             | 550                      | Hongshan District        | Luonan Road    | 17948.72                                       | Y                                           | N                                           |
| 15     | Chicory Square              | 4                             | 2                             | 480                      | Hongshan District        | Luonan Road    | 17948.72                                       | Y                                           | N                                           |
| 16     | Leduhiui                     | 4                             | 2                             | 310                      | Hongshan District        | Huanghelou Road | 26438.38                                      | Y                                           | N                                           |
| 17     | Weiga Baigang City          | 4                             | 2                             | 310                      | Hongshan District        | Luonan Road    | 17948.72                                       | Y                                           | Y                                           |
| 18     | Fanyue Mall                 | 5                             | 2                             | 480                      | Hongshan District        | Luonan Road    | 17948.72                                       | Y                                           | Y                                           |
| 19     | Luxiang Square              | 8                             | 2                             | 650                      | Hongshan District        | Guanshan Road  | 20645.16                                       | Y                                           | Y                                           |
| 20     | Guanggu International Plaza | 3                             | 3                             | 350                      | Hongshan District        | Guanshan Road  | 20645.16                                       | Y                                           | Y                                           |
| 21     | World City Plaza (Lingjiao Lake) | 5                         | 2                             | 620                      | Hongshan District        | Guanshan Road  | 20645.16                                       | Y                                           | Y                                           |
| 22     | Wanda Plaza                 | 4                             | 2                             | 710                      | Jiangnan District        | Beihu Road    | 29600.35                                       | Y                                           | Y                                           |
| 23     | Horizon Department Store    | 4                             | 2                             | 560                      | Jiang’an District        | Yongqing Road  | 40154.67                                       | Y                                           | Y                                           |
| 24     | RT-Mart                     | 4                             | 2                             | 450                      | Jiangnan District        | Hualoushuita Road | 35383.33                                      | Y                                           | Y                                           |
| 25     | M + Department Store        | 5                             | 4                             | 550                      | Jiangnan District        | Hualoushuita Road | 35383.33                                      | Y                                           | Y                                           |
| 26     | Wangfujing Department Store Store | 6                         | 3                             | 300                      | Jiangnan District        | Hualoushuita Road | 35383.33                                      | Y                                           | Y                                           |
| 27     | Grand Ocean                 | 5                             | 2                             | 360                      | Jiangnan District        | Hualoushuita Road | 35383.33                                      | Y                                           | N                                           |
| 28     | Wuhan International Plaza Block A | 7                         | 3                             | 470                      | Jiangnan District        | Wansong Road  | 14824.80                                       | Y                                           | Y                                           |
| 29     | Wuhan International Plaza Block B | 7                         | 3                             | 350                      | Jiangnan District        | Wansong Road  | 14824.80                                       | Y                                           | Y                                           |
| 30     | KaiDe Square                | 7                             | 3                             | 475                      | Qiaokou District         | Hanzheng Road  | 89717.97                                       | Y                                           | Y                                           |

*Source: Wuhan Local Records, 2016–2018. (http://dfz.wuhan.gov.cn/html/wh2019/default.shtml).
external open space of a commercial complex, following the calculation method in He Hui, Chen Yi, and Lin Xiaowu’s literature (Hui, Yi, and Xiaowu 2018).

The formula is as follows:

$X_1 = \frac{\text{total number of storefronts}}{\text{length of building the bottom interface}}$

Functional density refers to the number of POI* under the unit length of the space adjacent to the external space at the bottom of the complex (Hui, Yi, and Xiaowu 2018). (Figure 3)

$X_2 = \frac{\text{POI number}}{\text{building bottom interface length}}$

The hole coefficient ($X_3$) is the ratio between the length of the entrance of a commercial complex and the length of the building bottom interface (Hui, Yi, and Xiaowu 2018). (Figure 4)

*POI: Point of Interest. In a geographic information system, POI can be a house, a shop, a post box, a bus station. The POI in this paper refers to other functional spaces in the commercial complex other than the storefront.

4.1.2. Average transparency, brightness and saturation

The building interface on the ground floor of the commercial complex mainly consists of the following (Xu and Kang 2014):

(I) Open storefronts.

(II) Transparent interface: sight can go directly into the interior of the glass surface.

(III) Opaque window: With posters, people can only see certain depth.

(IV) VI. Solid wall (Figure 5).

When calculating the transparency, the author only considered the first two types and defined the transparency as follows:

Average transparency ($X_4$) = transparent facade length/building bottom interface length (Hui, Yi, and Xiaowu 2018)

The calculation of average brightness ($X_5$) and average saturation ($X_6$) was by taking the photos of elevation continuously and then putting the photos in Photoshop software made them to be two pixels. In this way, the color analysis of each photo was simplified into the two deepest and lightest main colors, and the average values of S (saturation) and B (brightness) could be obtained in HSB color mode.

4.2. Definition of behavior variables and measurement method

This research mainly studies the impact of urban interfaces on pedestrians around. The effect is reflected in three aspects of pedestrian behavior: the distance between pedestrians and the object under study, the degree of pedestrian aggregation near the object under study, and the speed of pedestrians passing by the object under study.

Considering the above three aspects, this research defined three behavior variables: average intimacy, average aggregation and average attraction as criteria for evaluation of open space.

4.2.1. Average intimacy

The average intimacy aims to discuss the relative position of people and complex in open space. The author measured the vertical distance \((L)\) from each point to the boundary of the building and the vertical distance \((l)\) from the building to its boundary by recording the position of the pedestrian retention points in the open space during three periods of working days (Figure 6). The specific quantification is as follows:

Average intimacy ($Y_1$) = \(\frac{L_1/l_1 + L_2/l_2 + \ldots + L_n/l_n}{n}\)

4.2.2. Aggregation degree

The aggregation degree aims to analyze the ratio of the pedestrian size in open space to that in the whole open space. The area size and average density of
different densities in the heat chart of population density were calculated.

\( S_1 \) and \( \rho_1 \) are the areas and densities corresponding to high-density regions, respectively, \( S_2 \) and \( \rho_2 \) are the areas and densities corresponding to the medium-density regions, respectively, \( S_3 \) and \( \rho_3 \) are the areas and densities corresponding to low-density regions, respectively (Figure 7).

Specific quantification method is as follows:

**Aggregation degree**

\[
(Y_2) = \frac{S_1 \cdot \rho_1}{(S_1 \cdot \rho_1 + S_2 \cdot \rho_2 + S_3 \cdot \rho_3)} 
\]

* Explanation of the formula: \( S_1 \cdot \rho_1 \) is equal to the number of people in the high-density regions, \( S_2 \cdot \rho_2 \) is equal to the number of people in the medium-density regions, \( S_3 \cdot \rho_3 \) is equal to the number of people in the low-density regions, \( \frac{S_1 \cdot \rho_1}{(S_1 \cdot \rho_1 + S_2 \cdot \rho_2 + S_3 \cdot \rho_3)} \) represents the ratio of the number of people in the high-density regions to the total number of pedestrians around the bottom of the commercial complex. This ratio can reflect the concentration of pedestrians.

Through the calculation of the relative ratio, the influence of the population based around the location of the commercial complex on the degree of aggregation can be excluded.

**4.2.3. Attraction degree**

The attraction degree aims to analyze the attraction degree of the commercial complex to open space pedestrian, which is defined as the average velocity of the pedestrian in open space and is also investigated through the pedestrian velocity thermal diagram. \( S_a \) and \( V_a \) are the areas and speed corresponding to the region with the fastest speed, respectively, \( S_b \) and \( V_b \) are the areas and speed corresponding to the region with the medium speed, respectively, \( S_c \) and \( V_c \) are the areas and speed corresponding to the region with the slowest speed, respectively (Figure 8).

Specific quantification method is as follows:

**Attraction degree**

\[
(Y_3) = \frac{1}{V} = \frac{(S_a + S_b + S_c)}{(S_a \cdot V_a + S_b \cdot V_b + S_c \cdot V_c)} \]

* Explanation of the formula: \( V \) represents the average walking speed of pedestrians in open spaces, \( V = \frac{(S_a \cdot V_a + S_b \cdot V_b + S_c \cdot V_c)}{(S_a + S_b + S_c)} \); \( \frac{1}{V} = \frac{(S_a + S_b + S_c)}{(S_a \cdot V_a + S_b \cdot V_b + S_c \cdot V_c)} \) can reflect the attractiveness of commercial complexes to open space pedestrians: the faster the average walking speed, the shorter the stay time and the smaller the attraction.
5. Analysis of data

5.1. Statistics of data

After the variable is processed by the quantization algorithm, the results are shown in Table 2.

How do these factors affect people's behavior in open spaces and to what extent depend on correlation analysis in SPSS software (Table 3).

5.2. Analysis of environment variables

According to Table 3, no significant correlation can be obtained between the Y variables. However, there is a positive correlation between store density and functional density and transparency in X variables. In order to ensure the rationality of independent variable factors and the accuracy of independent variable data measurement, it is necessary to find out the reason for the correlation between independent variables. The author gives the following reasonable explanation.

By analyzing the above results, there is an objective correlation between store density and functional density. For commercial complex, function density is bound to affect store density. Since each store has corresponding POI and non-store POI, such as entrance and exit, ATM, etc. The number of this non-store POI is in a relatively stable proportion of the total number of POI when statistical functional density is calculated. Therefore, the store density directly determines the total number of POI, hence they objectively having a positive correlation. Store density and functional density have a strong positive correlation with average transparency: the correlation coefficient between store density and average transparency is 0.473, between functional density and average transparency is 0.501. In the research process, it was found that for the complex with the same unit length interface, the higher the store density, the smaller the length of the interface occupied by each store.

Therefore, to attract customers in the limited length, the transparency would be improved as much as possible for these small stores. When the store density is very low, a single store can occupy a long building interface, so it does not need to open the entire interface. Such stores tend to make windows and posters, which would reduce the transparency. Some high-end shops with a long construction interface will also adopt shielding to reduce the transparency and ensure the privacy of customers.

5.3. Correlation analysis between environment variables and behavior variables

5.3.1. Attraction degree is strongly positively correlated with average transparency

During the survey, it was found that the aggregation degree usually has a strong relationship with the open space itself. For example, tables and chairs in the open space and the layout of the landscape platform would become the central gathering factors. In addition, some commercial behavior in the open space would lead to the phenomenon of onlookers, queuing, etc., which also have a substantial interference with the pedestrian behavior. At the same time, some incidental factors, such as sudden stopping to answer the phone and to take care of children, cannot be ruled out.

Figure 3. The diagram of store density and functional density.

Figure 4. The diagram of hole coefficient.
The correlation coefficient between attraction degree and average transparency is 0.547** (Significant level: * p < 0.05; ** p < 0.01), this positive correlation can be explained by the behavior of the pedestrian. The transparent interface would arouse people’s desire to explore the interior of the building, and it is easy for people to be attracted by the goods placed inside the building, thus leading to the increase of the attraction degree.

5.3.2. Intimacy degree is positively correlated with average saturation

The higher the average saturation, the higher the average intimacy is, the correlation coefficient between average saturation and average intimacy is 0.403* (Significant level: * p < 0.05; ** p < 0.01). It can be seen that the crowd prefers the facade of a high-saturation building. Because there are more bright advertising signs, it gives people a stronger impact...
on their vision, and the human eye is easily attracted by bright things.

5.3.3. **Attraction degree is negatively correlated with average brightness**

There is a negative correlation between the degree of attraction and the average brightness: the correlation coefficient between attraction degree and average brightness is $-0.407^*$ (Significant level: $^* p < 0.05$; $^{**} p < 0.01$).

Because the measurement time is during the summer day, the indoor environment inside the transparent window is darker than other parts of the building facade, resulting in the lower the brightness of the building facade. People are more likely to be attracted by the transparency facade of the building, which is in line with people’s curiosity.

Therefore, the lower the brightness is, the higher the attraction degree will be.

6. **Conclusions**

I. Use Store density, function density, hole coefficient, average transparency, brightness, and saturation to quantify the various facade features of the bottom-level interface of an open space-oriented commercial complex, and use Average intimacy, Aggregation degree, Attraction degree to quantify the behavior of pedestrians in open spaces around the bottom-level of a commercial complex.

II. By analyzing the correlation of quantitative data, the conclusion is drawn, there is a correlation between the characteristics of the bottom-level interface of commercial complex and the pedestrian behavior.
Correlation analysis between variables.

| Number Pearson
| correlation (2-tailed) | Store density (X1) | Functional density (X2) | Hole coefficient (X3) | Average transparency (X4) | Average brightness (X5) | Average saturation (X6) | Average intimacy (Y1) | Aggregation degree (Y2) | Attraction degree (Y3) |
|-----------------|---------------------|---------------------|-----------------------|------------------------|--------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| N = 30          |                     |                     |                       |                        |                          |                        |                        |                        |                        |                        |
| Store Density(X1) | 1                   | **.824**            | **.618**              | **.473**              | **−.372**                | −.212                  | −.011                  | .139                   | .123                   |                        |
| Functional Density(X2) | **.824**          | 1                   | .351                  | **.501**              | **−.444**                | −.293                  | −.024                  | .270                   | .168                   |                        |
| Hole Coefficient (X3) | **.618**          | .351                | 1                     | −.090                 | −.089                    | .070                   | .223                   | −.013                  | −.200                  |                        |
| Average Transparency (X4) | **.473**           | **.501**            | .090                  | 1                     | **−.516**                | −.325                  | .044                   | −.041                  | **.547**               |                        |
| Average Brightness (X5) | −**.372**         | −**.444**           | −.089                 | −**.516**             | 1                        | .587**                 | .086                   | −.328                  | −.407**                |                        |
| Average Saturation (X6) | −.212              | −.293               | .070                  | −.325                 | **.587**                 | 1                      | .403*                  | −.074                  | −.302                  |                        |
| Average Intimacy (Y1) | −.011              | −.024               | .223                  | .044                  | .086                     | 1                      | .011                   | .036                   |                        |                        |
| Aggregation Degree (Y2) | .139               | .270                | −.013                 | −.041                 | −.328                    | −.074                  | −.011                  | 1                      | .025                   |                        |
| Attraction Degree (Y3) | .123               | .168                | −.200                 | −**.547**             | −**.407**                | −.302                  | .036                   | .025                   | 1                      |                        |

Bold fonts indicate the related variables. (* p < 0.05; ** p < 0.01).

around: Attraction degree is strongly positively correlated with average transparency, which means the attractiveness of commercial complexes to surrounding pedestrians is strongly positively correlated with average transparency of bottom-level interface of commercial complex; Intimacy degree is positively correlated with average saturation, which means the intimacy degree of pedestrians around commercial complexes to commercial complexes is positively correlated with the average saturation of the color of the bottom-level interface of commercial complex.

III. Through the correlation test of the characteristics of the bottom-level interface of commercial complex and the pedestrian behavior around, the influence relationship is revealed, and provide a data foundation and design basis for future research and design practices of a better urban interface.

7. Recommendations

Through a series of field investigations and data analysis, the author puts forward the following conclusions and suggestions for the design of bottom-level interface of commercial complex and pedestrian-friendly bottom-level interface in urban space environment.

This research confirms that using store density, functional density, hole coefficient, average transparency, brightness and saturation to quantify the various facade features of the bottom-level interface of a commercial complex is feasible. In the future, it is necessary to add similar research and carry out research with more dimensions. In addition, there are still other essential elements that promote the spatial activity of the external interface of commercial complex need to be explored, and the method can also be applied to other urban spatial environment related research.

The database obtained by this type of research can be applied to the design of the external space interface of the commercial complex in the future, and the space applicability and effectiveness will be simulated and predicted.

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