Study on the Coupling Association between Human and House under the Influence of the Evaluation Index of Urban Residents' Behavior

Chenglin Gao¹ and Yaying Wang²,*

¹PHD. Teaching in the major of environmental design in School of Landscape Architecture (Beijing University of Agriculture), Beijing, 102206
²Corresponding author email: aziwyy@126.com.

Abstract. The interaction mechanism between people and houses in urban residential space is explained by the coupling relationship in the system of housing science. The mathematical model of the human house coupling association is derived by using the coupling relationship to explain the interaction mechanism of the people's house in the urban residential space. The mutual coordination system of the user, space and objective under the relationship of building and living behavior. The results show that: The residential space and residential behavior in Changping District of Beijing are entering a period of high-level coupled and coordinated development. Among them, the residential cultural indicators and their subsystems show positive feedback on the coupling relationship between residential behavior and spatial correlation. In the living space, moral education is the core that affects human behavior and spatial coupling. The sustainable role of the creation of the space environment, coupled to the indoor ecological environment and the outdoor natural environment; The coupling protocol of man and residence has dynamic and procedural properties, which rely on the behavior communication mode of the internal stage of the space to establish the spatial system of systematic variability.

1. Introduction
As the urbanization is continually accelerating and the the universal two-child policy is being liberalized, new family structures like "2+2+1" or "2+2+2" in modern cities have gradually become the mainstream, and an increasing number of families have higher requirements for the cultural value of dwelling space. The modern society stratification and the complexity of residents demands make the properties and boundaries of each functional space in the residential space system clearer, which affects the behavior of the residents' family activities and acts on the internal environment of the living space, triggering the interaction mechanism between them. In the internal construction process of urban dwelling space, forming the interaction relationship between human and house behaviors with the characteristics of system coupling. In this study, from the perspective of the integration of cultural and regional studies, the coupling theory is proposed to study the exchange, promotion and complementation between urban housing space and residents' behavioral elements. The coupling relation model between human and residence and the mathematical model of the coupling system and the SPSS coupling coordination degree evaluation method are applied to evaluate and analyze the relationship between urban residential space and residents behavior, and thus the sustainable development direction of residential space in the future is put forward.
2. Construction of Behavioral Function Indicators of Urban Residents

2.1 Orientation of Behavioral Indicators of Urban Residents
Under the influence of values, the inherent agent for the formation of urban residents' behaviors lies in cultural values, which can be constructed through people's needs and attitudes and lead people's behaviors. The living behavior index of residential space are mainly around the two primary target levels of "intangible and tangible" cultural value, including social culture, natural environment, spatial planning, association service and housing form. By selecting and analyzing 10 evaluation indexes, the new residential behavior index elements and characteristics are obtained (Table 1).

Table 1. Residential Behavior Evaluation Index under the Influence of Cultural Value

| Objective Level   | Spatial Index of Traditional Residence                           | Spatial Index of Modern Residence                  | Direction of Index |
|-------------------|-----------------------------------------------------------------|---------------------------------------------------|--------------------|
| Social Culture    | The social system under the influence of traditional Confucian culture | Socialist core values system                       | Forward            |
|                   | The orderly cultural ritual system                               | Sense of family belonging                          | Forward            |
| Natural Environment| Round sky and square earth                                       | Human-house system                                 | Forward            |
|                   | Natural imitation                                               | Nature imagery                                     | Forward            |
| Spatial Planning  | Facing south                                                     | Front living room and back bedroom                 | Backward           |
|                   | One bright room and two dark ones                                | Elastic distribution                               | Backward           |
| Association Service| Closed to the inside and open to the outside                     | Freedom and openness                               | Forward            |
|                   | Space independent function                                       | Engaging experience                                | Forward            |
| Housing Form      | Traditional techniques                                          | Diverse in shape                                   | Forward            |
|                   | Simple form                                                      | Technological upgrading                            | Forward            |

2.2 Behavior Index Characteristics of Urban Residents
The residential culture system produces significant influence on all respects of housing economic life in the family culture circle with the idea of homogeneity effect and extended family, which is mainly manifested in the interactive relationship between human and house behaviors with the characteristics of system coupling in the process of building the interior of the residential space. As the whole residential space is affected by policies, the shape and structure of family culture has a positive correlation guiding role for the residents' living behavior and the creation of a healthy environment in the space, which is mainly reflected in values, images and symbols. The behavior of residents and their utilization of housing interact with each other, that is, the greater the scope of activities of residents, the higher the utilization rate of their housing space will be. The coupling system of behavior and space mainly completes the non-positive index transformation of spatial planning and distribution by means of family communication service mode, spatial internal structure and modeling technical form, which is mainly manifested in the aspects of composition, orientation and form.

3. The Association Model of Human - House Coupling under the Action of Residents Behavior

3.1 The Coupling Function Interface between Residential Space and Residents Behavior
Based on the cultural system of the coupling relationship between human and residential behavior, different combinations of the elements of urban residential space have different influences on the interaction between residents and residential space. Since the human-house behavior coupling system is a system formed by the coupling of all subsets of elements, it is mutually permeated and coupled with the requirements of the housing culture mechanism and the characteristics of the coupling system.
Therefore, the coupling system function of housing space and resident behavior is constructed as follows:

\[
P = F(H, O, S, V, I, E, C, D, M) = A \times B = \begin{bmatrix} H \\ O \\ S \end{bmatrix} \times (V, I, E, C, D, M)
\]

P is the coupling system between residential space and residents behavior; H is Human; O is object; S is space; V is value; I is image; E is element; C is constitute; D is direction; M is morphology; A is the column vector, composed of H, O and S, which is the basic element based on the coupling relationship between human and house behavior; B is the row vector, composed of other elements V, I, E, C, D and M, which is the parallel element constituting the cultural system.

The matrix array of the coupling between residential space and residents behavior is obtained by analysis, which is concretely expressed as: In accordance with the increase or decrease of the number of the coupling system components, the column matrix of the components of the human-house behavior coupled system can be extended or scaled into squares of different orders; The combination of people, things and space value in the coupling system directly affects the benign operation of the urban residential system; Based on the difference in the operating efficiency of the residential function system, the coupling system can make the elements of the residential coupling system circularly combine with each other to form the layout planning and resource allocation scheme for the benign coupling development between residential behavior and space.

3.2 The Mathematical Model of Human - House Coupling
City Residential & User Behavior Coupling System (CR&UBCS) refers to an open set with specific functions, forms and features formed by interweaving, permeating and coupling of construction elements with different attributes (human elements, physical elements and spatial elements) in a specific space, with the connotation of its coupling relationship described as follows:

\[
CR \& UBCS \subseteq \{ K_1, K_2, K_3, R_{el}, R_s, G, T, L \}, K_i \subseteq \{ J_i, N_i, Z_i \}
\]

K1, K2 and K3 respectively represent the three types of construction elements of people, objects and space; Ji, Ni and Zi respectively represent the elements, structure and functions in the ith cultural system of CR&UBCS; Rel is the coupling set of cultural system, which is the coupling relation set in CR&UBCS, related to both the coupling among the three elements and the coupling relationship between the detailed elements within the three elements; Rst is a set of factors restricted or constrained by construction elements; G is the target set of cultural system; T and L are time and space variables respectively. Under the coupling relationship between urban residents and houses, the coupling relationship among K1, K2 and K3 lies in the emphasis on the combinational relationship among the three elements (as independent variables) of people, objects and space based on their respective functions. If the interior space of the house is regarded as dependent variable or test index y, the coupling element is independent variable or test factor X=(x1, x2, ..., xn), then the coupling relation can be regarded as the functional relation \( y=f(x) \), whose function is to connect the coupling elements. The correlation mathematical model of human-house coupling is derived (Figure 1).
4. Case Sample Evaluation under the Action of the Model

4.1 Case Sample Analysis Method
The two-child families in Jinmaofu Community, Vanke Community and China Resources Community in Changping District, Beijing were selected as sample units, and the coupling relationship and the coupling coordination degree between human and residential behaviors of different families to the inner space of urban residence were statistically analyzed. According to statistics, these three communities are close to the time zone ring, their geographical location is close, and their real estate sales are among the top. The case samples were analyzed by combining the human-house coupling relationship model, the mathematical model analysis of the coupling system and the SPSS coupling coordination degree evaluation method. Different from the study on the physical properties of the coupling of two entities from the physical perspective, in this study, the connotation and thinking method of the coupling theory of the interaction system between human and residential behavior of the urban residential interior space construction were mainly analyzed. As for the application of coupling theory, it focuses on the interpretation of the explanation of the action relation between residents' behavior and the inner space of urban housing, including the action index, the action forms and the degree of coordination, etc.

4.2 The Application of Mathematical Model
The behavior coupling of urban residential space was analyzed emphatically, that is, the coupling correlation system between urban residential space and residents. By combining the above research results and referring to the capacity coupling coefficient model in physics, the coupling degree model of the three subsystems was obtained:

$$Q = \sqrt{\frac{(U_p \times U_m \times U_s)}{[(U_p + U_m + U_s)/3]}}$$

(3)

$Q$ is the degree of coupling; $U_p$, $U_m$ and $U_s$ are the comprehensive evaluation indexes of human, object, and space subsystems respectively. $Q \in [0,1]$, the larger the $Q$ value is, the stronger the interaction among the three subsystems is, and vice versa. Coupling degree can only show the degree of interaction between subsystems, but can not reflect the level of coordinated development.

With random sampling method, in March 2019, 324 questionnaires were distributed to residents of Vanke, China Resources and Jinmaofu communities in Changping District, Beijing based on the proportion of 10.8% of total households (the average proportion of two-child families), and 300 questionnaires were statistically valid. In view of the residents' behavior reflected in the effective sample data, 20 households were selected as a group, so that the coordination degree analysis results of the coupling system of urban residents and houses in Changping District, Beijing were obtained (Table 2).
Table 2. Analysis on the Coordination Degree of CR&UBCS in Changping District, Beijing

| Sample Number | Coupling Degree Q | Coordinating index U | Coupling Coordination Degree W | Coordination Level | Degree of Coupling Coordination |
|---------------|-------------------|----------------------|--------------------------------|-------------------|--------------------------------|
| 1~20          | 0.900             | 0.758                | 0.818                          | 8.667             | Good coordination              |
| 21~40         | 0.879             | 0.608                | 0.724                          | 7.667             | Intermediate coordination      |
| 41~60         | 0.903             | 0.627                | 0.746                          | 8.083             | Good coordination              |
| 61~80         | 0.913             | 0.669                | 0.774                          | 8.167             | Good coordination              |
| 81~100        | 0.905             | 0.667                | 0.770                          | 8.417             | Good coordination              |
| 101~120       | 0.875             | 0.615                | 0.730                          | 7.750             | Intermediate coordination      |
| 121~140       | 0.885             | 0.746                | 0.804                          | 8.333             | Good coordination              |
| 141~160       | 0.889             | 0.629                | 0.737                          | 7.917             | Intermediate coordination      |
| 161~180       | 0.906             | 0.650                | 0.762                          | 8.000             | Good coordination              |
| 181~200       | 0.934             | 0.660                | 0.781                          | 8.333             | Good coordination              |
| 201~220       | 0.884             | 0.690                | 0.772                          | 8.167             | Good coordination              |
| 221~240       | 0.894             | 0.840                | 0.902                          | 9.283             | High quality coordination      |
| 241~260       | 0.912             | 0.729                | 0.804                          | 8.500             | Good coordination              |
| 261~280       | 0.938             | 0.669                | 0.779                          | 8.250             | Good coordination              |
| 281~300       | 0.931             | 0.700                | 0.799                          | 8.667             | Good coordination              |

According to the partition table of coupling coordination degree, \( W \in [0.6, 0.7) \) is primary coordination, \( W \in [0.7, 0.8) \) is intermediate coordination, \( W \in [0.8, 0.9) \) is good coordination, and \( W \in [0.9, 1.0) \) is high quality coordination. According to the research data, dwelling space and residents behavior are a pair of interactive coupling functions, and the variations of residents behavior affect that of residential spatial structure. Good and high-quality coupling coordination degree accounted for 84.62% of the total sample, among which, \( Q \) value of 0.89 indicates that in the residential space, the interaction between various elements is strongly correlated, proving that the residential space and residential behavior in Changping District (5-6 ring Road), Beijing, are entering an advanced coupling coordination development period, with the average coordination degree of 0.67 among all elements, which is a good coordinated development on the whole. The coupling relationship between residential culture index and its sub-system on residents’ behavior and spatial correlation presented positive feedback.

4.3 Result Evaluation

The behavior activities of family residents are mainly manifested as follows: in the family activities of residents, the related cultural life elements of moral education have a guiding effect on the number of family behaviors. Their space is realized by means of emotional dialogue, family activities and communication between people, which can improve people’s social morality and cultivation.

The use of spatial forms is mainly manifested in the organization of residential tools that match space with the consciousness and mobility of residents. In other words, under the coupling effect of different family members and activity time, the public space or learning space can meet the requirements of parent-child reading, game interaction, puzzle model and other entertainment methods, presenting phased spatial forms.

The functional structure of the spatial interface is mainly reflected in the actual action of people, objects and space in the coupling interface. As can be seen from the variation tendency of the spatial demand index, the subject behavior of the space pays more attention to the joint participation of parents and children, which realizes the sequential relation of the coordinated operation of the space. With the help of the experience of modern digital technology, the frequency and value of space usage are increased.

5. Conclusion

The residential space and residents behavior in Changping District, Beijing are entering a phase of
advanced coupled coordinated development, which is a good coordinated development on the whole. Among them, the residential culture index and its subsystems show positive feedback to the coupling relationship between residents behavior and spatial association. The coupling relevance between residential space and residents behavior is reflected in the practical effects of people, objects and space in the coupling interface. The creation of space environment is coupled to the sustainable function of nature imitation, and the coupling agreement between human and house has the attributes of dynamic and process. The coupling system of diverse residents behaviors and space can complete the transformation of positive indicators of spatial planning distribution via the service mode of family communication and the internal structure of the space, establish a variable spatial system.

On the basis of the coupling system of urban residents and houses under the action of mathematical model, with the CR&UBCS mathematical model operation model, it can be concluded that the life factors associated with cultural value in family activities have a guiding effect on the number of family behaviors, reflected in the organization of spaces and housing tools that match the consciousness and mobility of the inhabitants. The ambiguity of coupling interface can be utilized to realize the sequence relation of coordinated operation of space diversity and increase the interaction between human and space and a coordinated development of efficiency and quality in the use of space, to acquire the comprehensive benefits of society, economics and environment.

6. References
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