PEDESTRIAN NETWORK TRANSFORMATION PROCESS OF
THE HISTORIC TOWN TONG-LI, CHINA - an illustration of the
self-organization law

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Abstract

This paper analyzed the urban transformation process of Tong-li town in southeast of China by space syntax theory and method. It is a historic water town in Jiangnan area, and a popular tourist spot in that region. The focus of this research is on how the self-organization law of urban form has its effect on the land-use distribution in both the 19th and 21st century and also the current behavior patterns. To explore the full picture of the cognition map of this historic water town, the author established three types of axial model: the internal street network, the external traffic system, and a combined model of internal and external traffic. Each of these three models has a 19th Century’s version and a 21st century’s version. For the external traffic system, it was a water network in the 19th century and is a road network in 21st century, because the main external traffic mode formerly were boats and presently are vehicles. To compare the form and function relationship, the author reviewed relevant historic records and conducted a detailed behavior investigation in this town by gate count and snapshot methods.

There are four main findings we got. First, there is always a suitable form-function relationship for this town. If we only look at the internal street models, in both 19th century and now, the main successful shopping streets are almost located on the most integrated axial lines. Secondly, by a comparison of the three models in a same period, we found a coincidence of the integration cores for the three 19th century’s models, but a distinct difference for the 21st century models. That is to say although the integration core of the internal traffic model and the one of the combined model are almost on the same location, but the integration core of the external traffic model and the internal traffic model are very different from each other. This
phenomenon may due to the fast recent-development, which means the city didn’t have enough time to adjust itself to follow the self-organization law. Thirdly, we found a vivid illustration of the self-organization law in this current town. There is a street which was a important shopping street in the 19th century and converted into a residential street in 20th century. In order to boom the travel economy, the local government converted it again to shopping street a few years ago. However, this effort didn’t gain success. This story can be well explained by the axial models. This street had its spatial importance when the waterborne traffic was pivotal, and lost its importance when there are no more boats taken goods at present. The final finding started from a question that whether the behaviors of the residents and visitors are shaped by different spatial attributes. By gate count, we find the movement pattern of residents and visitors are quite different from each other. A statistic analysis suggested that the choice measure is good to explain the movements of residents better than the integration; while the global integration measure can better explain the movements of visitors.

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1. INTRODUCTION

1.1 Background

In Historic water towns of Southern Yangtze River Regions, local spatial characters, life patterns and cultural landscape are formed by the interactions between local residents and natural environment. Although the types of historic towns present in diverse, all the residential spaces are focusing on water system and following with streets and alleys. The interweaved river network not only forms the framework for the spatial development of historic towns but also takes the role of connecting with the outside world. They determine both relationships between different historic towns and their connection with surrounding towns; internal streets which are growing constantly are depending on natural rivers and well-found artificial environment, meanwhile, associating with living spaces and activities which are separated by river network. Rivers and streets which have a complementary relation are the diachronic spatial accumulation of local human behavior; the formed spatial configuration, in turn, effects residents’ behavior and activities; as a result, it presents the self-organized character formed by the interaction between space and society.

However, at present, the step-by-step self-organized development mode of historic towns is facing challenges from external environment: on one hand, traditional water transportation is replaced by land transportation, such as railways and highways which causes “water-centered” life style to disappear; on the other hand, the fast development of the tourist industry attracts a great number of visitors to change town’s function from “living” to “visiting”; namely, space for inhabitants’ daily life is turned to be scenic spot providing travelers with a different experience.
1.2 Objective

The purposes of this paper are as following:

1) Under these two external interventions in social process, has the spatial configuration of historic town been changed?

2) What kind of changes happened?

3) Does these original local spatial configuration influence external social process?

This article tends to focus on Tong-li—an entirely preserved historic water towns in Southern Yangtze River Regions to analyze the relationship between spaces of historic towns and the social process from views of pedestrian space and its utilization.

2. METHOD

This research uses the space syntax approaches for systemic description, model construction and objective analysis. For the study of historic pedestrian space, this article applies the “axial model”, namely, using the fewest and longest lines to cover the research district in order to construct the axial map for the historic town, meanwhile, systematically analyzing the relationship between configuration characters resulted from space syntax method, the use of pedestrian spaces and human beings’ activities.

For the study on the use of space, in diachronic research, it mainly depends on historic maps and local chronicles. For the study of existing conditions, it applies “Gate Count” to sum the volumes of different kinds of people with different activities; from fixed-point observation of movements related to certain type of activities, it recorded the density and intensity of activities and finished the “Activity Map” to gain static data.

3. REFINEMENT OF RESEARCH QUESTION

Tong-li located in northeast of Wujiang, Suzhou, Jiangsu Province, is a typical water town of Southern Yangtze River Regions. Its water area accounts for 1/5 of total land area. The form of the historic town presents in bulk-like style, separated by 49 bridges and 15 rivers, and results in 7 irregular residential blocks. In these residential blocks surrounded by water networks, the pedestrian spaces organize residents’ daily movements and their outdoor lives, which form beautiful and detailed town texture and build up a spatial systems made of the main streets, secondary roads, alleys and lanes (Figure 1).
Tong-li is also a typical commercial town in Southern Yangtze River Regions, with distinctive consumer behaviors. In Song Dynasty, it was already a commercial base for merchants; River S and River L located in southwest of Tong-li, as boat entrances for the historic town, had became a commercial district concentrated around Street S; Until Qing Dynasty (17th-19th century), the southern town had been a commercial centre for its region containing a 1.5km Z-shaped commercial street passing through Street XD, Street ND, Street DD, Street ZX and Street XT(Figure 2-a). Generally, its commercial district was in the south and the residential area was in the north. Due to the rapid economic growth and the improvement in the quality of life, the historic town attracted a great number of people from other places to live there; meanwhile, it presented complicated relationships constituted by landlords, bureaucrats, merchants, civilians (fisherman, craftsman and peddlaries) and residents from surrounding villages. The first four categories were living in the town while the last category were exchanging agricultural by-products in the
small town market to become the protagonist of those economic activities, at the same time, to service for local residents’ daily life. In the 1950s of last century, the fair trade was turning down and at present, the commercial area focuses on Street ZX, Street ZC and Street MX (Figure 2-b).

![Figure 2. Main Commercial Street: a) 19th century; b) (2009)](image)

In the history, Tong-li and the outside world were only connected by boat. Until the 1980s of last century, both the traffic mode and external traffic environment were changed significantly, forming a new transportation manner that relies mainly on land traffic while making water traffic subsidiary. The Songbei Highway and City Ring Road are the main connectors to the outside; the 1.5m wide Street MJ is widened to be Street ZC which is the main street to connect the centre of town and the outside world; as a result, the situation of limited transportation is changed. According to the diachronic study of the space, this article analyzes the effects of traffic mode change—from water to land as their main transportation to the outside, on the pedestrian spatial form of the historic town.

From 1986, due to the strict preservation policy for the 0.87 km² historic town of Tong-li, the traditional spatial structure and water-street system are well preserved. At present, the historic town has been a scenic spot with closed management; each entrance is set barrier but most of the local residents can enter freely; except for some large houses such as Tuisi Garden and Songshiwu Garden are set to be scenic spots but most of the residents are still living in traditional houses and well retained their life styles; therefore, residents’ daily lives and visitors’ activities are mixed together. This article through the synchronic study of activities, analyzes whether the spatial configuration has different influences on the behaviors of different categories of people, further to influence the use of spaces.
4. CORE SPACE'S SHIFT IN THE HISTORIC TOWN UNDER THE CHANGE OF TRANSPORTATION

This part tends to illustrate diachronically the relationship and the changes between the core space of historic town and the public spaces. The study depends on two maps drawn in different periods: one is the Reign of Jiaqing (19th century) while the other is 2009 that help to finish the axial maps for analyzing the morphology and the characters of the pedestrian spaces in that historic town. The Reign of Jiaqing was the most flourishing period for Tong-li in the past, as both the population and the town size are at the highest in their history; in addition, in Jiaqing 15th year (1810), the town map is a relatively complete historic map with dependable evidences.

4.1 Core Integration Analysis of the Pedestrian Space

Considering the traffic differences between the two periods, it develops three models to analyze the characters and the interrelationship of the internal and external spatial network of the historic town.

First of all, it sets up model 1 and analyzes the water network of the 19th century and the road network of 2009 separately: in the Reign of Jiaqing, the most integrated lines of the water network model are located in River S in the southwest and River Y in the northeast (Figure 3-a); in 2009, the most integrated lines in the road network model are Road A and its connector Road B which is a primary carriageway for entering the historic town(Figure 3-b).

![Figure 3](image_url)

Figure 3. Integration (Rn) of external spatial network: a) (19th century); b) (2009)
Second, it builds up model 2 and illustrates the pedestrian spaces of the historic town in the two periods separately: in the 19th century, the integrated lines of the pedestrian network are dispersed, next to River S and River Y which are most integrated in the water network model, showing a high degree of correlation (Figure 4-a); in 2009, well-integrated lines are clearly concentrated around Street ZC which is in the middle of the town; although the integrated line is connected with Road B, it has no strong relation with the external traffic system (Figure 4-b). From the above analysis, it can be found that: in the 19th century, it shows a high degree of correlation between the integration cores of the internal and external traffic systems, which responds to Dai X’s study on Suzhou. We can say that the integration core of the traditional pedestrian spaces in the historic town are more determined by external water network with outward characters; however, at present, the pedestrian spaces grow inward, the integration of which are more affected by the change of its internal road system while the external road network plays an indirect role through its adjustment of internal road network.

Third, it builds up model 3. The external and internal traffic systems of the historic town cooperate in whole. Especially in historic times, water network was the determinate factor for the spatial development in historic Tong-li, closely related to the pedestrian spatial system. It can be said that the pedestrian spaces’ generation are depending on its structure of water network of the historic town. Therefore, if the external and internal systems are put together, the spatial configuration of the historic town can be represented visibly. In the detailed analysis, pedestrian axial lines are directly connected with highway axial lines while the pedestrian system and water system are separated at the interchange but connected at the connection of water-land traffic systems, such as pier or port. Comparing the overlaid maps in two different periods, it can be found that: 1. In the 19th century, integrated axial lines are dispersed on the whole while in 2009, they are concentrated in the layout. 2. In the 19th century, the most integrated axial lines are located in the west of the town, containing Street DD, Street ND, Street ZX, Street TZ, Street ST, Street DX, River L, River S and River Y which are the most integrated lines in the pedestrian or water networks, showing a high degree of correlation; in axial map of 2009, the most integrated lines are aggregated around Street ZC and both sides (Figure 5). Therefore, it presents the integration core shifted from west to the centre of the town (Figure 6).
4.2 Analysis of Land Use

The most integrated lines shift from the west to the middle of the town which is in agreement with the trend of the main commercial street also from the west to the middle. Is it a coincidence or an inevitable
result? Below, through the analysis of land uses, it will further explore its correlation to the integration value of pedestrian spaces in the two different generations.

In the 19th century, the historic town is constituted of three main functions: commercial residential streets, public facilities (such as ancestral halls, temples and colleges) and a large area of residential blocks. The commercial streets are the core public spaces of the historic town used by every resident in the town and traders from outside villages. For the further investigation of the relationship between the integration of pedestrian spaces in the historic town and the locations of commercial streets, important public facilities and large dwelling houses, it can be found that: the commercial streets are concentrated on the most integrated axes apparently covering the most integrated area in the historic town; other public facilities such as ancestral halls, temples and colleges which are for the use of residents are located on relatively less integrated axes; however, a large amount of residential spaces are situated in much less integrated areas. It is demonstrated that the accessibility of land uses is directly related to the integration of pedestrian spaces in that historic town, which means the district division of the historic town depends on the pedestrian spatial network. Although Tong-li is the commercial centre for its surrounding region, surrounding villagers’ trading activities are restricted in the southern town’s commercial blocks so as to maintain the northern residential blocks’ quietness and privacy. In addition, the commercial blocks are located at the junction of the most integrated axes of water and land traffic systems, which clarifies the characters of consumer behaviors in Southern Yangtze River Regions; compared to the social factors in terms of religions or clans, the spatial development of historic Tong-li is more influenced by economic factors for the trade (Figure 7-a).

At present, the main function of the historic town is for living and visiting, as the development of tourism adds new tourist attractions and facilities, the public infrastructures are shifted according to residents and visitors. From the comparison of the layout of public facilities and the integration of axial lines, it can be found that: 1. Commercial facilities for the local residents and public infrastructures such as cinema, post office and bank are apparently concentrated to the most integrated axial lines in a compact manner; 2. Tourism facilities providing visitors with shopping, dining and guiding also tend to focus on the integration core of the historic town axial map, except for a few gift shops which are located near the tourist attractions or between the scenic spots. It presents that the commercial facilities and public infrastructures providing services for local residents are still on the most integrated axes and attracting parts of the tourism facilities to concentrate here (Figure 7-b).

It can be found that the integration core in the pedestrian spatial model of historic Tong-li has an intimate relation with the form of external water network, that also amplifies the spatial characters related to commercial activity with water transportation in Southern Yangtze River Regions; in addition, through the organization of the pedestrian network, it controls dwellers’ activities in residential blocks by hierarchy. However, at present, the shift of external environment and internal road network leads to the change of pedestrian spatial configuration of that historic town. Its integration core is detached from the external water network and situated in the centre of the town, further to influence land uses. Especially, the location of the commercial centre is shifted and further to attract neighborhood facilities and tourism infrastructures to concentrate there which helps to achieve the internal public function of the centre of the historic town.
5. THE INTEGRATION OF OUTDOOR ACTIVITIES UNDER TOURISM BACKGROUND

The above shows the influence of the change of external environment to the pedestrian spatial form of the historic town, and this part will further investigate tourists’ effect on the use of pedestrian spaces in the town. After 2004, visitors’ population increases rapidly, achieving 1,000,000 for the first time, while in 2008, the amount exceeds 3,000,000. Classic space syntax does not consider people’s social differences in the analysis but in this study, through the cross check of residential and tourism activities, it will find how the pedestrian spatial form of the historic town influences different categories of people’s route choices and activity layout.

5.1 The Relationship of Pedestrian Activities and Integration

From the preliminary comparison of the pedestrian density of residents and visitors (density> 150 people/h) and the integration value of the axial map, it can be found that: the pedestrian density of the residents and visitors is correlated to the integration value of pedestrian spaces; the integrated axial lines are accompanied with high density of residents and visitors; in the reverse, less integrated axial lines correspond to low density of pedestrians. There are some streets, namely, Lane LJ, Lane TT and Street MQ whose integration values are irrelevant to the volume of residential pedestrians, mainly because of the surrounding residents’ density; the integration values of Three Bridge scenic area, Street MQ and Street DD(tourism commercial street) are completely irrelevant to their visitors’ densities due to the dispersed tourist attractions and commercial facilities’ directly effects on visitor’s route choices so as to reduce the impact of spatial configuration(Figure 8). For the further investigation of the differences between the above two objects, from the comparison of the residents and visitors’ pedestrian density and the integration value, it can be found that: there is a strong relationship between the integration value of the axial map and the
visitors’ pedestrian density, that means from the residential correlation coefficient $R=0.541$, the coefficients of determination can be calculated $R^2=0.292$, $p=0.0001<0.05$ (Table 1); tourist correlation coefficient $R=0.710$, the coefficients of determination $R^2=0.504$, $p=0.0001<0.05$ (Table 2). It is demonstrated that although the tourism facilities strongly attract visitors, compared to local residents, the tourists’ activities are more influenced by the pedestrian spatial network.

![Figure 8](image-url). Density of pedestrians and Main Commercial Street and important public building: a) (Resident); b) (Visitor)
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### Correlations

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**. Correlation is significant at the 0.01 level (2-tailed).

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**Table 1. Relationship of residents' densities and integration**

**Table 2. Relationship of visitors' densities and integration**

### 5.2 Two Conjectures

What makes tourist pedestrian density has a higher degree of correlation with the spatial integration than that of the residents?

The first conjecture: the residents are more familiar with the pedestrian environment of the town than visitors, and easy to form certain walking modes, namely, when the spatial configuration is changed, their behaviors still can be remained. Commonly, local residents like to “take a short cut”; from the study on the relationship between the choice of axial lines and pedestrian movement, it can be found that, choice and the correlation coefficient of residential pedestrian density $R=0.773$, can help to calculate the coefficients of determination $R^2=0.598$, $p=0.0001<0.05$(Table 3); from the correlation coefficient related to tourist pedestrian density $R=0.665$, the coefficients of determination $R^2=0.442$, $p=0.0001<0.05$ is obtained(Table 4). Apparently, for the residents, choice and the correlation with pedestrian movement is more efficient than the spatial integration. It demonstrates that their pedestrian movements are more related to daily living, choosing the most reasonable and convenient routes which is different from external tourists' activities for visiting and experience.
The second conjecture: as there are many waterfront pedestrian spaces in the historic town, presenting the trend of gradual change, typical axial maps may not reflect the spatial cognition of people; therefore, from the segment analysis on the pedestrian spaces of the historic town, it can be found that the most integrated spaces are located in the Three Bridge district directly related to residents’ use of the spaces. In this article, the idea has not been totally verified and needs more study on it.

Therefore, from the existing study result, under the influence of destinations such as scenic spots and tourist commercial streets, the pedestrian movement density of external visitors has a higher degree of correlation with the spatial configuration than local residents, which means the irregular pedestrian spatial network and the hierarchy relation of the historic town will influence the route choices of visitors and control the field of residential areas. However, the residents are more familiar with the entire pedestrian environment of the town, and their route choices are more affected by travel purposes and the needs for spatial quality such as convenience, safety, comfort or happiness levels, so that they are able to give an overall consideration to their route choices.
6. CONCLUSIONS

From the analysis of the spatial configuration evolution and its influences in the historic town of Tong-li, it can be achieved the following conclusions:

1) The shift of the traffic mode is the main factor to influence the pedestrian spatial configuration of the historic town Tong-li. The developed regional water network and the active urban-rural economy help the spatial development of the town in Southern Yangtze River Regions. Tong-li’ growing up depends on the convenient water transportation and the pedestrian network relies on the growth and refinement of the water network framework. Therefore, there are strong correlation between the integration core of the pedestrian spatial configuration and the external water network, presenting outward characters apparently. Inside the town, it forms a hierarchy relation for the division of residential area. The introducing of modern transportation cause the change of external traffic environment and internal road network in the town, and the integration core of the pedestrian spatial configuration departs from the connection with the water network locating in the centre of the town which further leads to the shift of land uses. Especially, the commercial centre is sensitive to the change of spatial configuration, and its location is highly correlated with the new integration core, which is presented in an inward layout, intimately related to the daily life of the residents, further to attract the concentration of other neighborhood and tourism facilities to emphasize the public function of the town centre.

2) The external tourists’ pedestrian activities have a higher degree of correlation with the spatial integration of the pedestrian spatial configuration than the local residents. The original irregular pedestrian network and street blocks in its hierarchy still affect on visitors’ spatial cognition and route choices; meanwhile, visitors’ route choices are also influenced by the spatial layout of scenic spots and tourism facilities, which indicates that if the scenic spots and tourism facilities are well related to the existing pedestrian network, organizing the sightseeing route depending on the spatial configuration, the tourism industry will well integrated to the regional development; local residents are more familiar with the entire pedestrian environment than visitors, and their route choices are more affected by travel purposes and the needs for spatial quality such as convenience, safety, comfort or enjoyment, so that they are able to give an overall consideration to their route choices. Therefore, it is not correct to simply combine the procedure of spatial cognition and the spatial configuration. The gap between the density of pedestrians and the spatial cognition verifies that spatial cognition is a complicated process influenced by different factors.

In short, the application of space syntax for the analysis of the pedestrian spatial morphology of Tong-li and the fully understanding of real social structure, not only benefit for investigating the development law of historic town spaces under different cultures, to find the truth of the study object, but also support us to protect the present historic town of Southern Yangtze River Regions from multi-scales, multi-levels and multi-directions, not just from architectural spatial forms which are incomplete, static and exterior; they also help the spaces better serve for the local residents and visitors, from the use of the reaction of existing spatial form of the historic town.

7. REFERENCES


