

A Study on Temporal-Spatial Behavior Pattern of Working People in Medium-sized Squares within High-Density Central Districts—Taking Nanjing as an example

Shi Yi^{1*}, Hu Xinyu², Jiang Ying²

¹ Department of Urban Planning, Southeast University, Nanjing, Jiangsu, 210096, China

² Department of Urban and rural planning, Nanjing Forestry University, Nanjing, Jiangsu, 210037, China

* Corresponding author's e-mail: shiyi@seu.edu.cn

Abstract. Working people are the main demographic in medium-sized squares within high-density central districts. Therefore, the temporal-spatial behavior pattern of these people can be inductive to square designs. By analyzing the human trajectories of working people in medium-sized squares in high-density central districts, this study explores the correlation between working people and squares. The Gulou, Daxinggong and Hanzhongmen squares were selected in this study, with the research time starting from 7:00 am to 8:00 pm, to record the human trajectories of working people of the four different types with a half-hour interval. Questionnaires were also used to investigate these people. And the CAD and Excel are adopted to summarize the collected data. The final conclusion is arrived at through a comparative analysis of the data of the older-aged groups, young and middle-aged groups, teenagers and children, providing reference for square designs.

1. Introduction

As the core of urban public activity system, high-density central districts are the most concentrated areas of political, economic and cultural activities in cities, concentrating a great deal of people, material and information stream. High-density cities show evident characteristics of high-density space environments from their land use, district buildings and traffic organizations. Therefore, it's impossible to build large-scale squares in high-density central districts. Squares in these districts, integrating transportation, rest and communication, are major places of leisure activities for elder people and children as well as of communication activities for young and middle-aged population. The utilization rate of squares always peaks on working days. Past researches on square designs put too much emphasis on spatial layout, but ignored human behaviors. We cannot scientifically grasp the relationship among various elements of square designs, neither can we create space environment that meets the needs of consumers, unless we have a good understanding of people's psychology and behavioral characteristics and rules. How to build medium-sized squares with high utilization rate in high-density central districts is an important issue that must be solved. Therefore, the study of the temporal-spatial behavior pattern of working people of medium-sized squares is imminent.



2. Research Contents and Methods

High-density intensive models refer to the models of urban land utilization characterized by integration, diversification, high development density and intensive urban layout. High-density cities usually have dense and prosperous centers. As the most prosperous and important areas in cities, city centers can clearly demonstrate the high density of cities, such as Beijing, Shanghai, Nanjing, Hangzhou, Taiyuan and so on; and squares in high-density central districts have the largest stream of people. Since they are located in central areas of high-density cities, the areas of these squares are limited to small and medium size. There are many squares in Nanjing, namely the Gulou Square, the Daxinggong Square, the Zhong Shan Men square, the Lakeside square, the Sunshine square, the Hanzhongmen square, the Gulou Square and so on. The Da Xing Gong, Hanzhongmen and Gulou Squares were selected in this study. They all belong to the medium-sized squares within high-density central districts and are located in the hinge of transportation, reflecting the pedestrian flow of entire central district.

Located in Gulou District, the Gulou Square is situated at the intersection of the five main roads and two branch roads. It is an important transportation hub in Nanjing. Flanking the square to the south is the Jiangsu Radio and Television Studio; the north are the Telecom Building, the multimedia Building and etc; the east the Asia Catherine square. The square's structure altitude is high in the west and low in the East, developing a main east-west axis with the fountain as the core. In the middle of the square is a flag-pole, abutting on which is a semicircular waterfall. To the east is found rigid pavement while to the west is a large area of lawn and trees, as well as some stone benches for pedestrians. The Daxinggong Square is located in Nanjing Chang Jiang Road of Xuan Wu District. To the north of it is the Nanjing presidential palace; the south is the Central Hotel; and the west is the Nanjing library. Besides, the central axis of Nanjing presidential palace and the entrance of the new building of Nanjing Library are exactly opposite the square. And the Han Fu cuisine variety street is situated at its north side. There are fewer benches in the north side and more open spaces in the center of the square. To the south of the square are small patches of land raising above the level ground that are paved with hard materials. Located in Qin Huai District, the Hanzhongmen square is situated at the southeast corner of the intersection of the Hanzhong Road and Huju Road. Flanking the square to the north side is the Nanjing University of Traditional Chinese Medicine; the southeast part the Shek Kwu Road housing district, the South Huju Road housing district and so on. The north side of the square's gate tower is a large area of open spaces and the east the Sunken Square. The north side of the square is the idyllic green belt and the south the Greenway.

3. Analysis of Human Trajectories on Weekdays

3.1. The Characteristics of Human Trajectories on Weekdays

The human trajectories on weekdays often occur in traffic areas and residential areas. The trajectories of working people of the same type have similar characteristics in the same time period, and recurring feature at different time's periods. The trajectories of working people of different types also show similar characteristics in the same time period. However, they are regularly distributed at different time periods. The Gulou, Daxinggong and Hanzhongmen squares are all located in central areas of high-density cities, around which there are a lot of public transport like subways and buses and housing districts. Therefore, human trajectories of the three squares are affected by traffic and residential areas in general. But the difference is that the Daxinggong Square, located at the center of Carrefour, the Nanjing library and Nanjing Presidential Palace, is also affected by nearby tourist attractions and stores; while the Gulou Square is near the Asia Catherine square and the litchi square that have a huge people flow, and it is also adjacent to the Jiangsu TV where gather a large number of working people. Therefore, its human trajectories on weekdays are affected by the surrounding business activities.

3.2. The Analysis of Human Trajectories of the Gulou Square

Located in Gulou District, the Gulou Square is situated at the intersection of the five main roads and two branch roads. It is an important transportation hub in Nanjing. In this study, we marked all entrances of the Gulou Square by using the letters A through H to record the human trajectories of people of four different kinds. From 7:00 am to 9:00 am on weekdays, most of the elderly tend to enter the square from entrance B; they walk past the spacious lots on the east side and leave there from entrance E. From 9:00 am to 1:00 pm, they choose to enter from entrance H or E and leave from entrance B along the washroom. From 1:00 pm to 5:00 pm, on the contrary, they usually enter from entrance H but leave from entrance E, D or C. From 5:00 pm to 8:00 pm, they either choose to enter from entrance H and leave from entrance E, or enter from entrance C and leave from entrance E or G. 7:00 am to 9:00 am is the rush time for the elderly to do morning exercise. To the north of the square gather a large number of residential areas. The entrance B is the nearest entrance to the square, and the east side of the square is spacious for the elderly to do morning exercise and walk through. However, the situation from 9:00 am to 1:00 pm is contrary to that from 7:00 am to 9:00 am. That is to say, most of the elderly choose to leave from entrance B. From 1:00 pm to 5:00 pm, they always gather at the square from different places to do various leisure activities. 5:00 pm to 8:00 pm is the rush time for the elderly to walk or dance square dance. Therefore, they usually enter the square from entrance H and entrance C. From 7:00 am to 11:00 am on weekdays, most of the middle-aged and young people tend to enter the square from entrance H and leave there from entrance E. From 11:00 am to 5:00 pm, on the contrary, they usually enter from entrance C but leave from entrance G or D. From 5:00 pm to 8:00 pm, they choose to enter from entrance D or entrance C and leave from entrance H. 7:00 am to 9:00 am is the morning rush time for the middle-aged and young people. The entrance H is near the subway station and the entrance E the business office areas and bus stations. Therefore, most of the middle-aged and young people choose to walk through the Gulou Square. 11:00 am to 3:00 pm is the lunch hour for the middle-aged and young people, and the entrance C and entrance D are near the Litchi square, making them the best choice for those people to have lunch or work. 3:00 pm to 8:00 pm is the rush hour for the middle-aged and young people to go off work. As a result, they usually choose to leave from subway entrance H. From 7:00 am to 11:00 am and from 3:00 pm to 8:00 pm on weekdays, most of the teenagers either choose to enter the square from entrance C; namely they walk past the spacious lots on the east side and leave there from entrance E; or enter from entrance D or entrance E and leave from entrance H. 7:00 am to 11:00 am is the lunch hour for teenagers to go to school and 3:00 pm to 8 pm to leave school. The entrance E is large and near the bus station, and the entrance H is a subway entrance. Therefore, most of the teenagers choose to leave from entrance E or entrance H. 7:00 am to 9:00 am on weekdays, many children choose to enter the square from entrance B; they walk past the spacious lots on the east side and leave there from entrance C. From 1:00 pm to 5:00 pm, they usually enter the square from entrance C and leave from entrance H. They often go to the square on weekdays accompanied by an old person. As a result, their routes are usually the results of the subjective options made by the elderly. In general, they choose to enter the square from entrances set near their housing districts.

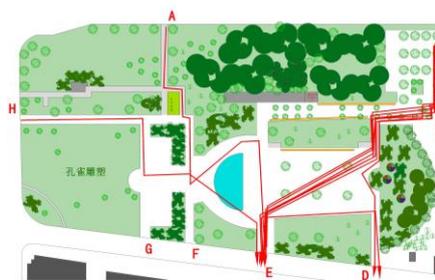


Figure 1. Human Trajectories of the elderly at 7 to 9 o'clock in Gulou Square on weekdays

3.3. The Analysis of Human Trajectories of the Daxinggong Square

The Daxinggong Square is located in Nanjing Chang Jiang Road of Xuan Wu District. In this study, we marked all entrances of the Daxinggong Square by using the letters A through H to record the human trajectories of people of four different kinds. From 7:00 am to 9:00 am on weekdays, most of the elderly tend to enter the square from entrance F; they walk past the shade tree section in front of Carrefour and leave there from entrance E. They may also choose to enter the square from entrance F or entrance D, and leave from entrance A, B or C. From 9:00 am to 1:00 pm, they choose to enter from entrance A or entrance G and leave from entrance F or to enter from entrance B or C and leave from entrance F. From 1:00 pm to 5:00 pm, they choose to enter from entrance A or entrance G and leave from entrance E or to enter from entrance B or D and leave from entrance F. From 5:00 pm to 8:00 pm, they usually enter the square from entrance D and entrance E and leave from entrance B. Around the Daxinggong Square gather a large number of residential areas. Entrance A, B and C are located near the residential areas. Entrance F is located between central intersections and the Nanjing Library. Entrance F, on the other hand, is situated the bus station. 7:00 am to 9:00 am is the rush time for the elderly to do morning exercise. Most of the elderly will go to the market to shop for food from 9:00 am to 1:00 pm. Therefore, they will choose to enter from entrance E, where Carrefour is situated. Carrefour is situated near the Nanjing Library, making it a place for the elderly to kill time from 1:00 pm to 5:00 pm. There are numerous residential areas around the Daxinggong Square. Many teenagers will gather here to engage in a variety of activities from 5:00 pm to 8:00 pm. Most middle-aged and young people may choose walk past the Daxinggong Square from entrance A and leave from entrance G from 7:00 am to 11:00 am on weekdays; or they may choose to enter from entrance A and B that situated near the residential areas and leave from entrance D, E and F. 11:00 am to 3:00 pm is the time for the middle-aged and young people to have a lunch break. As a result, most of them choose to enter the entrance from entrance A, D and E and leave from entrance F. While from 3:00 pm to 8:00 pm, they either choose to enter from entrance A and leave from entrance E or enter from entrance D and leave from entrance C. 7:00 am to 11:00 am is the morning rush time for the middle-aged and young people. As a result, they will choose enter from entrance D and E or G and F, where gather a large number of bus stations or subway stations. 3:00 pm to 8:00 pm is the time to return from school or work, making abode be a critical standard for the middle-aged and young people to choose their routes. Most teenagers will enter the square from entrance F and leave from entrance B from 7:00 am to 11:00 am on weekdays. 3:00 pm to 8:00 pm is the rush hour for teenagers to go home after school. Therefore, they tend to choose their routes on the basis of the location of their homes. They may either choose the E-A route or A-E route. Around the Nanjing Presidential Palace gather a large number of elementary and middle schools. Entrance B is close to these schools, and entrance F is situated near the subway station. As a result, most teenagers will choose a route convenient for them to go to school and return home. Most children choose to enter from entrance F and entrance C and leave from entrance E or G after staying for a short time at the square's opening spaces from 7:00 am to 11:00 am on weekdays. From 7:00 am to 11:00 am, most teenagers select their routes on the basis of transportation factors like bus stations. Those staying at the square to play usually go to the Children's House of Nanjing Library. Most human trajectories recorded from 1:00 pm to 5:00 pm were left by children staying at the square, most of them choosing to enter from entrance C situated near the residential areas or entrance F spacious in space and leave from entrance C and entrance D after playing at the square.



Figure 2. Human Trajectories of the elderly at 7 to 9 o'clock in Daxinggong Square on weekdays

3.4. The Analysis of Human Trajectories of the Hanzhongmen Square

Located in Qin Huai District, the Hanzhongmen square is situated at the southeast corner of the intersection of the Hanzhong Road and Huju Road. In this study, we marked all entrances of the Hanzhongmen square by using the letters A, B, D, G and H to record the human trajectories of people of four different kinds. From 7:00 am to 9:00 am on weekdays, most of the elderly tend to enter the square from entrance H and entrance G and leave from entrance D. From 9:00 am to 1:00 pm, they choose to enter from entrance A and leave from entrance D. From 1:00 pm to 5:00 pm, on the contrary, they either choose to enter from entrance G but leave from entrance D or enter from entrance D and leave from entrance A. From 5:00 pm to 8:00 pm, most of the elderly choose to enter from entrance A and leave from entrance D that situated between the Hanzhongmen square and surrounding residential areas. Most of the elderly will walk past the square to do morning exercise. From 9:00 am to 1:00 pm, they usually enter the square from the subway entrance A, through which they return home later. In the afternoon, some old people will gather at the Hanzhongmen square to play cards, dance square dance or do other things. Therefore, most of the elderly will go to the square by subway to join these activities. After supper, the old people usually walk to the square to join some elderly activities and walk back home after that. Most middle-aged and young people choose to enter the square from entrance D and leave from entrance H from 7:00 am to 11:00 am on weekdays. People enter the square from Entrance D; and entrance H is a subway entrance. Therefore, most middle-aged and young people will choose their routes on the basis of their work places. They choose to enter from entrance A and entrance G, and leave from entrance D from 11:00 am to 3:00 pm; while 3:00 pm to 8:00 pm is the rush time for the middle-aged and young people to return from work. As a result, they enter the square from entrance A and H and leave from entrance D. 7:00 am to 11:00 am is the rush hour for teenagers to go to school. Therefore, most teenagers choose to enter from the subway entrance H and entrance A. From 3:00 pm to 8:00 am, they walk through the square from entrance H and leave from entrance A or entrance D. From 7:00 am to 11:00 am on weekdays. Many children tend to choose to enter and leave from Entrance D or entrance H. They usually stay at the opening spaces between the two walls of the square. While they usually choose to enter from subway entrance H or entrance A and leave from entrance D from 1:00 pm to 5:00 pm. As a result, a large number of children will gather at the Hanzhongmen square in the afternoon.



Figure 3. Human Trajectories of the elderly at 7 to 9 o'clock in Hanzhongmen Square on weekdays

4. Conclusion

Most of the human trajectories of the elderly recorded on the three squares were left when they did some exercise or carried out leisure activities such as square dance. All old people can do morning exercise, chat with friends or dance square dance at three squares respectively. And that is an important reason why they choose to go to squares. Most of the elderly start from their home to these squares every day, making location of their home become an important factor in their selection of routes. Most human trajectories of the elderly are found in the vicinity of roads with large green areas and lots of benches. Besides, internal environment and infrastructure provided by the squares also have certain effect on their trajectories. Compared with the other two squares, human trajectories of the elderly left in Daxinggong Square can also be found near entrance D and entrance E, where Carrefour is situated. That means Carrefour also exerts an effect on the human trajectories of the elderly. Most human trajectories of the middle-aged and young people are the results of their work events. By analyzing the survey findings of the three squares, we can find that human trajectories of the middle-aged and young people are mostly found near the entrance of transportation hubs. Gulou Square can also be found in office area E and business district C besides entrance H. That is to say, business activities also have an effect on the human trajectories of the middle-aged and young people. Most human trajectories left by teenagers are found in the vicinity of schools. By analyzing the survey findings of the three squares, we can find that human trajectories of teenagers mostly occur in shortest paths leading to transportation hubs, demonstrating that transportation is the most affective factor to human trajectories of teenagers. Besides, most human trajectories of teenagers occur in the widest roads, which are often affected by the internal layout of squares. Human trajectories of teenagers in Gulou and Daxinggong Squares are more diversified compared with those in the Hanzhongmen square, distributing near entrance H leading to the Nanjing Library and entrance E and entrance C leading to Litchi square and Asia Catherine square respectively. Most human trajectories left by children are the results of play, following a devious route. Human trajectories left by children in the three squares all occur in the widest areas. Hanzhongmen Square in the widest roads between the two walls; and those found in Daxinggong Square centrally distribute in spacious opening spaces with large green areas. Thus it can be seen that the internal layout, environment and infrastructure in squares work together to affect the human trajectories left by children. Those trajectories of children found in Daxinggong Square can also be found between Carrefour and Nanjing Library. That is to say, surrounding buildings near the square also exert an effect on the human trajectories of children.

By analyzing the human trajectories, stopping places and results from questionnaire of the three medium-sized squares located in high-density central districts on weekdays, we can find the inadequacies as well as some references places of the three squares. The Gulou Square is better equipped compared with the other two squares: The Daxinggongand Square are short of necessary facilities such as bathrooms; besides, human trajectories of Gulou Square can also be found in places

with bathrooms. It means public facility construction is necessary. By comparing the human trajectories of the three squares respectively, we can find that trajectories with a high flow density mostly occur in transit-oriented roads. That is to say, a large number of people may gather in transit-oriented roads over a fixed time period. We can increase the size of the entrances and reduce the quantity of the entrances with lower population flow at the same time to avoid the congestion of the entrances and disperse the flow of people.

As a saying goes that: “Stones from other hills may serve to polish the jade of this one.” We can summarize the design and development strategies of city squares in high-density central districts based on the analysis of the three squares, providing a reference for city square construction: Firstly, we should take the surrounding environment into consideration when constructing squares in high-density central districts to increase the space efficiency of squares. Secondly, humanistic layout also should be taken into account in the construction of medium-sized squares. It means that we should construct city squares from the perspective of “people-oriented”. Thirdly, the government should actively encourage enterprises to invest more money to build more opening spaces through economic stimulus. Finally, we should design and construct city squares according to people’s requirements. We should design more “people-oriented” city squares on the basis of different needs of different groups of people to encourage the public to participate in outdoor activities and social events.

References

- [1] Rutledge, & Albert J. (1981). *A visual approach to park design*. Garland STPM Press.
- [2] Haarhoff, E. J. (2014). *Shaping places: urban planning, design and development*. *Urban Policy & Research*, 32(1).
- [3] Gianni, & Savarro. (2014). *Urban space in the individualistic era: architectural theories and public city in Italy*. *US-China Public Administration* (6), 492-502.
- [4] Frederik Stjernfelt. *Locale, Street, Square—a Naive Theory of the City*[J], 2008, 21(3):105-113.
- [5] Meng, Q., & Kang, J. (2015). *The influence of crowd density on the sound environment of commercial pedestrian streets*. *Science of the Total Environment*, 511, 249-258.
- [6] Hou Xiana, Zheng Lipeng. (2017). *Simulation of Pedestrian Flow in Traditional Commercial Streets Based on Space Syntax*. *Procedia Engineering*, 2017, 205.
- [7] Marcus, C. C., & Francis, C. (Eds.). (1997). *People places: design guidelines for urban open space*. John Wiley & Sons.
- [8] Thompson, C. W. (2002). *Urban open space in the 21st century*. *Landscape and urban planning*, 60(2), 59-72.