Experimental design of real human parking behavior in laboratory

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Abstract. With the development of advanced technology, the current people all the time by the impact of a variety of information, Therefore, the parking choice behavior under a lot of information is widely studied in the academic field. At present, there are three main research methods about parking behavior: mathematical analysis, simulation and experimental research. Mathematical analysis method mainly used mathematical model to describe the daily travel of the walker balance or gradual equilibrium choice. The simulation method can simulate the traffic reality and reflect the dynamic characteristics of the traffic system. The experimental study is based on the establishment of controlled experimental environment, in the travel information feedback to study the actual decision-making behavior of the subjects. In this paper, we establish a scenario experiment scheme for real people in virtual environment, For specific experimental problems, that is, the real man parking choice behavior under the action of information, To carry out a fine scene design, highlighting the effective control of the variable, According to the virtual environment provided, to carry out a controlled real human experiment, in order to conduct an in-depth study of parking behavior. Through the experimental study, it can be concluded that the parking information and the driver's parking experience play an important role in reducing the parking time, At the same time, it can also be concluded that the complete parking information is more conducive to the driver's more successful completion of the parking behavior.

1. Introduction

With the rapid development of advanced technology, a large number of traffic information directly acts on the individual, and the problem of parking behavior under the influence of many information has aroused wide attention of researchers. At the same time, with the rapid development of economic and the ascension of the number of private cars, the parking problem It is urgent to be resolved. Generally speaking, the scientific research methods includes mathematical modeling, computer simulation and experimental methods and so on. At present, the research results are as follows: the Logit model in non-aggregation model is the commonly models used in exploring behavior at home and abroad. Based on Logit model, Zhang Baoyu¹² selects the parking fees, walking distance, quality of service and number of free parking, and based on these, a probability model of a particular parking lot selected by the parking is established to change the choice behavior of drivers. Based on the survey of parking area in the Beijing business district, Guanhongzhi³ and others⁴⁵ analysis the preference of the users of parking lot to choose travel mode in different policies. Yao Shengyong and others⁶⁷ made an investigation in Beijing central business district to investigate, a selection model is established based on it, which this model is
on the parking time, and used to study the relationship between the parking behavior and parking fees. ZongFang\cite{8} established a Bayesian network, and used Bayesian network to study the parking behavior and the relationship between parking policy and parking information. However, In terms of the parking behavior, although there are human participation participated in the real environment experiment method, and the experiment result is credible, it also faces the restriction of the cost, the experiment organization and the law and so on, on the other hand, the computer simulation method is convenient, but faces the question of authenticity, And the assumptions of mathematical modeling are too much to largely ignore the complexity of human choice behavior. Therefore, integrating the advantages of real human experiment and simulation, this thesis builds real human + virtual environment scenario experimental program in order to carry on the deep research on parking behavior.

2. The experiment

2.1 Description of experimental

Through the controllable traffic behavior experiment, the parking behavior of real people- parking decision process is discussed. The entire experiment was conducted on a strict request and the experiment was a paid experiment. The reward for each participant was determined by the results of multiple rounds of travel options which are the scores obtained in the experiment. Therefore, the experimental results are true and credible.

2.1.1 The explanation of parking behavior experiment controllable variable

(1) The choice of parking lots are two in the experiment, numbered: ①, ②.
(2) The starting point be set as A is A, and the destination location be set as B in this experiment.
(3) The description of parking information:
   1) No parking information at all.
   2) incomplete parking information, namely: the distance of the starting point to the two car parks, the distance between the two car parks and the distance of the two car parks to the destination.
   3) the complete parking information, namely: the distance of the starting point to the two car parks, the number of parking spaces remaining in both car parks, the distance between the two car parks, waiting time and seeking time and the distance of the two car parks to the destination B.

2.1.2 Selection of subjects and the relevant requirements

Thirty subjects were recruited through a network platform, and all participants had not previously participated in similar experiments. All participants were not allowed to communicate with each other after reaching the experimental site. And throughout the course of the experiment, subjects were asked to make selection decisions, which each representing a stop, the choice of decision-making only includes the selection of parking lot.

The participants in this experiment will be divided into three groups, the first group do not know the parking lot of information; the second group know the incomplete information of the parking lot; the third group know the complete information of the parking lot.

2.2 Design of experimental

2.2.1 Design of the experimental situation

The experiment scenario was set to require subjects to arrive at a fixed end point (from home to mall) from a fixed starting point every day. Subjects were asked to choose the parking lot, so that they can reach their destinations in the shortest possible time as far as possible.

2.2.2 Design of parking

In order to avoid the introduction of too many complex uncontrollable factors, it will be limited to two parking spaces in this experiment, namely: ① and ②, participants in the experiment only need to
make decisions in the two parking lots. The specific design is as follows:

1. Parking lot ① is a large parking lot, and parking lot ② is a small parking lot; A departure from the parking lot ① is 10 minutes by car and from ② parking lot is 15 minutes; Parking lot ① form parking lot ② is 10 minutes;

2. Considering that there are the waiting time (namely, queuing time) and the seeking time in the real parking process, we set the number of the Parking lot ① is 7 free parking spaces, the parking lot ② is 3 Free parking;

3. The queuing time is set to 5 minutes, taking into account the more number of vehicles entering the parking lot the more time to find the park, this experiment will design the seeking time to the following time (as follow Table 1)

| The number of vehicles entering the parking lot (vehicles) | Seeking time (minutes) |
|-----------------------------------------------------------|------------------------|
| 1                                                         | 2                      |
| 2                                                         | 4                      |
| 3                                                         | 6                      |
| 4                                                         | 8                      |
| 5                                                         | 10                     |
| 6                                                         | 12                     |
| 7                                                         | 14                     |
| 8                                                         | 16                     |
| 9                                                         | 18                     |
| 10                                                        | 20                     |

4. Considering the effect of walking time after parking which drivers will take into account on the real parking decision, the parking lot ① is designed to be 5 minutes away from the destination B; parking lot ② is designed to be 8 minutes away from the destination.

5. This experiment is designed to be able to stop safely in the final, so subjects can change the choice of parking lots halfway according to the specific circumstances in order to enable themselves to reach their destinations with the shortest possible time.

Design of parking behavior shown specifically in Figure 1:
2.2.3 Design of subjects scored
In the experimental scenario of this study, the participants started from the starting point A and were required to complete the parking decision in the shortest time and reach the end point B every day. After the end of the experiment, based on the subjects selected results, we will get their respective use, and make a ranking, in order to give a certain reward and punishment.

2.2.4 Design of subjects rewarded
The experiment is a paid experiment, and the reward for each subject depends on the decided outcome of multiple rounds of parking, namely, the time from A to B in the experiment. Based on the 30 yuan / person of experimental cost, we will give reward and punishment of 0 to 10 yuan according to the score of the subjects after the end of the experiment.

2.3 Experimental procedure
Before the experiment, participants were instructed to understand the experimental content according to the description of the experiment, which they were not allowed to communicate with each other during this period. Subjects who have any questions about the description of the experiment can be explained through the experimental explanation staff by raising their hands. In other hands, Before the start of the formal experiment, the subjects have test selections of two rounds to understand the whole experiment process and the status of the parking lot. the experimental schedule of parking behavior of is specifically as follows:

| Number of Experimental Group | Rounds |
|-----------------------------|--------|
| The First group             | 1      |
|                             | 2      |
|                             | 3      |
| The Second Group            | 1      |
|                             | 2      |
|                             | 3      |
| The third group             | 1      |
|                             | 2      |
|                             | 3      |

Figure 2 Experiment screen shot of behavior of parking selection
The specific operation of the experimental process are:

The first group of participants was completely unaware of the parking lot information, and made decisions based on personal experience and experience gained after each round.

The second group of subjects in the experiment were informed of incomplete information of the parking lot by the laboratory staff before the experiment.

The third group of subjects in the experiment were informed of complete information of the parking lot by the laboratory personnel before the experiment.

3. Parking behavior experimental results analysis

After the experiment, the experimental results of the parking choice behavior of the individual subjects are obtained. As the experimental subjects are aware of the whole experimental procedures and rules, and the experiment is done in a fair and strictly prohibited environment. Therefore, the experimental results of this experiment is true and reliable, these can be used as the original data to analyse. The specific data analysis as follows:

3.1 Analysis between the same group

![Experimental time line chart of Complete no parking information group](image)

The figure 3 shows that under the condition of complete no parking information, the experiment is relatively high as a whole. After the first round of the experiment, experimenters obtained some experience, which makes the second round of the experimental results have a larger change, the 10 experimenters of the experimental use of time have decreased, but the 10 experiments’ experiment time have a large gap, ‘Some people’ experimental time up to 35 minutes, while some people use less time only 21 minutes. Due to obtained experience from the first two rounds of the experiment, the experimental time of the third round becomes more uniform, and the overall use time has declined, but also has a experimenter, his experimental time up to 37 minutes. This shows that only by experience and no parking information, in the case, it is likely to make the wrong decision, making the parking with a longer time.
Figure 4: The experimental time line chart of Incomplete parking information group

According to figure 4, due to the parking information is not complete, the experimenters in the parking choice can not be fully considered, they can only use the existing information to make the most favorable choice. From the experimental results, it is showed that most of the experimenters chose a large parking lot. This leads to the shortage of parking spaces, which makes the whole experimental time in a higher state. Through the first two rounds of experiments, subjects found the problem and made adjustments in the third round experiment, This makes the number of two parking spaces compared with the remaining parking spaces, declined in experimental time, got a Ideal result.

Figure 5: The experimental time line chart of complete parking information group

According to figure 5, In the condition of knowing the complete information about the parking lot, the experimenters made an analysis on the existing information, weighing all the factors and choosing the suitable parking scheme. From the experimental results, we can know that the first round of the experiment, the number of selecting two parking lots is the same, This shows that some people think that the large parking lot is more favorable to their own, some people think that using shorter time is more favorable to their own. of course, the subjects made such choices are not separated from their own characteristics. In the gradual learning experience and make the corresponding adjustment process makes the experimental results tend to be stable, and the experimental time also declined.
3.2 The same round analysis between different groups

![Graph showing experimental time for different groups](image6.png)

Figure 6 shows that, due to the three groups obtained the information of the parking lots is different, which has a very large impact to makes parking options. At the same time, because of the first round of the experiment, the lack of parking experience, which greatly affects the results of their experiments. This is shown in Figure 6, each of the experimental results fluctuations are larger. But through careful observation can still get to know that the experimenters who had complete information compared to the other two groups, the experimental results are relatively stable, and experimental time is relatively little. It can be concluded that the experience of the experimenters and the parking lots have an influence on the parking choice behavior, and the parking information has a more great impact.

![Graph showing experimental time for different groups](image7.png)

According to figure 7, In the case of less experience and different parking information level, the experimental results of the three groups compared with the first round are more volatile, the experiment time is more uneven. The reason for this is mainly in the lack of experience time, they got little experience. Parking experience has an important influence on parking behavior.
According to figure 8, although they have different parking information, through the accumulation of experience and information, the experimenters can also find in a relatively balanced state, so that their experimental results are stable, each subject experiment with all decreased. Therefore, when relevant departments set parking management policy, they need to consider various factors, distinguish between primary and secondary, in order to develop a measure to ease the pressure on the parking.

### 3.3 Analysis the overall time of each round experiments

| Group number | The first group | The second group | The third group |
|--------------|----------------|-----------------|----------------|
| The first round | 315 | 304 | 295 |
| The second round | 292 | 318 | 284 |
| The third round | 280 | 278 | 269 |

For table 3, analysis by column, from the left to the right, the parking information is more and more complete, the total experimental use of each column in each group decreased in turn. This shows that after repeated experiments, the experimenters will gradually accumulate experience, in the process of accumulate experience, the subjects gradually found a way to reduce parking time, so as to further illustrate the parking experience has an important influence on the parking choice behavior; analysis by row, the more parking information is obtained, the less time will consume. In the case of knowing the complete information of the parking lot, that is, the third group, its overall experimental time has been maintained at a lower level. On the whole, the third round of the third group is the least used in all experiments, 10 experimenters’ experimental time is 269 minutes, the average time in every person’s experimental time is 26.9 minutes, this is a very good result. In a word, the parking information and the driver’s parking experience has an important role in reducing the using time of parking. But in real life, parking experience is the individual characteristics of the driver, is an uncontrollable variable, so the relevant management departments should pay more attention to this important influence factors of parking information, in order to develop a reasonable measure to ease the pressure of parking.
4. Conclusion
In this paper, through the analysis of the existing methods of parking behavior, combining the advantages of two aspects of experiment of real people and Simulation, A scenario experiment method was established for the combination of the real person and the virtual environment, On the one hand, this method is real people involved, which can reflect the complexity of human's choice behavior, and improve the authenticity and reliability of the experimental results, On the other hand, it can save manpower and material resources in the virtual environment, which also can avoid the limitation of the experimental organizational and legal aspects. Therefore, this method provides a new idea for the study of some specific issues in the field of transport. Of course, there are some deficiencies in this paper: First of all, the future of parking selection process should not be confined to the car travel mode, in order to provide better quality and more convenient parking service for the parking lot, "P + R" and other travel mode should be include in, to make the application scope of the parking choice expanded. Secondly, this paper sets the parking lot is only two, too simple, At the same time, it's just a simple choice for them to parking, it is different from the real situation. Although there are some shortcomings, the new method of the virtual environment in the laboratory is still very desirable. It can be used to analyze the relationship between parking decision and the individual attribute, the trip attribute, the parking property, and so on, which is helpful to understand the characteristics of parking decision making, On this basis, we can further diagnose the city parking problem, put forward and evaluate the effect of the implementation in parking fees and other management policies.

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