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Study on the Social Psychology and Behaviors in a Subway Evacuation Drill in China

GE Xiao-xia, Dong WEI, JIN Hong-yu *

Department of Fire Fighting Commanding, Armed Police Academy, Langfang 065000, China

Abstract

The paper presents the psych-physiological laws of evacuation crowd in subway. Passengers who take part in Evacuation drill that was hold in the Taiyang Palace Subway in Beijing were survyed by questionnaire. The basic data was acquired. Then, psychological responses, behavior characteristic in the pre-evacuation and evacuation phase were researched, and the key effect factors were put out. The results show that slight tension was the main state of main state of mind. the first observation of the surrounding circumstances and then start the evacuation behavioral response was a major way. 92.9% of the total crowd began to evacuate in the 60s. Herding behavior and Familiarity-following was less, and the age, gender, and experience was the key factors that affect evacuation results.

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Keywords: evacuation drill; subway; psychology; behaviors

* Corresponding author. Tel: +86-316-2068561; Fax: +86-316-2068561.
E-mail address: gexiaoxia@wjxy.edu.cn.

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1. Introduction

Subway is the key transport means for big cities all over the world. It is developed rapidly for cities in China. Everyday, about four million people go in and out in Beijing subway, the problem on the crowd escape safety is concerned. In the past, Many tragedies were happened such as subway fire in Daegu, Korea in 2003, fire in The Yonghe Palace Subway, china in 2008. These accidents led to a great number of people die and evacuation.

Therefore, it is important to research evacuation problem in subway. At present, the research on subway evacuation safety mainly carried on the relation build structure and efficiency of evacuation by simulation[1-3], study on the crowd psychology and behavior is limited[4-5].

The objective of this paper is to obtain laws of behaviors and psychology in emergencies using survey data collected after evacuation drill in china subway.

2. Evacuation Drill

Evacuation drill was hold in The Taiyang Palace Subway in Beijing, and passengers were investigated. In the evacuation course, crowding and blocking up were taken place at the entrance of staircase, escalator.

After evacuation drills, passengers were asked to complete a questionnaire by teams of researchers positioned outside, but not impeding each emergency exit. A total of 197 valid questionnaires were acquired.

3. Method

3.1. Questionnaire

Occupant’s basic information, psychology response, pre-evacuation behaviors and evacuation behaviors were acquired by the way of questionnaire.

3.2. Analyze Method

Data analysis consisted of Frequencies techniques, Bivariate and Anova analysis to model using the Statistical Package for the Social Sciences (SPSS)

4. Basic Information

Basic information of the Occupant was listed in Table 1. A proportion of male and female is correspond. Half of the crowd had training experience, over 70% the total of the Occupant pay attention to evacuation signs.

| Characteristic parameter | Sex          | Age    | Training experience | Attention evacuation signs |
|--------------------------|--------------|--------|---------------------|---------------------------|
|                          | man          | woman | 20-30   | 31-40 | ≥41 | yes | no | yes | no |
| Number                   | 123          | 74     | 121     | 61   | 13  | 74  | 122 | 144 | 52 |
| Percent                  | 62.4%        | 37.6%  | 52.1%   | 31.3%| 6.7%| 37.8%| 52.2%| 73.5%| 26.5%|
5. Discussions

5.1. Psychology Characteristics

Psychology response of different sex was present in Table 2. Slightly panic was main psychology response. In female, the number of keep calmness person was less, however, terribly panic was more.

| State of mind      | Frequency | Valid Percent |
|--------------------|-----------|---------------|
|                    | man       | female man    | female        |
| keep clam          | 45        | 7             | 22.8          | 3.6          |
| Slightly panic     | 69        | 54            | 35            | 27.4         |
| terribly panic     | 9         | 13            | 4.6           | 6.6          |

5.2. evacuation Behavior

5.2.1 Pre-evacuation phase

(1) Behaviour Response

Fig.1 the first behavior response in the pre-evacuation phase. Immediately evacuation, look around, give an alarm phone were the highest three behavior response. The amount of the occupant that had been escaping in 60s was 92.9%.

(2) Decision-making course

Decision-making theories assume that a person, even under a danger situation, can still make rational decisions, attempting to achieve good outcomes and objectives in the situation. In the evacuation drill, Statistics on decision-making course of the crowd was listed in the Table 3. The crowd that made the decision were 84% of the total number of the crowd. It were effectively prevent these people straying into dead-channel, and could be more smoothly evacuation.

| State of mind          | Frequency | Valid Percent |
|------------------------|-----------|---------------|
|                        | man       | female man    | female        |
| seek hide place         |           |               |               |
| lose one’s head         |           |               |               |
| immediately evacuation |           |               |               |
| look around             |           |               |               |
| give an alarm phone     |           |               |               |
| dispose event           |           |               |               |
| inform some body        |           |               |               |
| hit alarm in the building |         |               |               |

Fig.1 The first behavior response in the evacuation drill

Table 3 Statistics on decision-making course of the crowd
(3) Pre-evacuation time

Pre-evacuation time was the key important to the crowd. pre-evacuation time was listed in Table 4.

Table 4  Statistics on Pre-evacuation time

| Time    | Frequence | Percent(%) |
|---------|-----------|------------|
| ≤10s    | 78        | 39.8       |
| 10-30s  | 69        | 35.2       |
| 30-60s  | 35        | 17.9       |
| ≥60s    | 14        | 7.1        |
| total   | 196       | 100        |

Table 4 shows that 92.9% of the total crowd began to evacuate in the 60s. In the evacuation drill, the crowd were quick to evacuate, the pre-evacuation time is short. Two reasons lead the results. One was that the occupant were informed before the drill. The other was 37.8% of the occupant own training experience.

5.2.2 Evacuation phase

(1) evacuation route

In the evacuation, the crowds had three kinds of exit to choose, these were come in entrance, the nearest exit and emergency exit. Statistics on evacuation exits that the crowd were chosen was listed in Table 5. The results showed that 20.3% of the total crowd chose to come in entrance as exit, 39.6% of the total crowd chose to leave the evacuation to the nearest exit, 40.1% of the total crowd chose to emergency exit. Nonadaption behaviour as Familiarity-following was low, only 20.3%. But nearly half of the crowd chose the emergency exit to evacuate. That the crowds make right choice attributed to the escape train, it makes the crowd had certain understanding of the escape common sense. The tendency of to the blind familiarity-following was avoid.

Table 5  Evacuation exits that the crowd were chosen

| Exit                | Frequence | Percent(%) |
|---------------------|-----------|------------|
| Come in entrance as exit | 40        | 20.3       |
| The nearest exit     | 78        | 39.6       |
| Emergency exit       | 79        | 40.1       |
| Total               | 197       | 100.0      |

(2) Evacuation group

Evacuation groups that the crowd were chosen was listed in Table 6. The results showed that 45.9% of the total number of the people were leader-following, accounting for 33.2% of the people according to evacuation signs, 10.2% of the people following friend or familiar people, 10.7% following more people group to evacuate. Thus, Nonadaption behaviour as following the familiar people and more people group was low proportion, only 10%. Therefore, in the evacuation drills, herd-following behavior was not appear.

In the same time, Table 6 showed also that the gender affected evacuation groups that people were chosen. In groups of women, who chose to Leader-following accounted for a larger proportion, was 57.5%. It was higher than proportion of the male chose to Leader-following in the male group. The difference value was 18.5%. Compared to men, the famels were more amenable to management, and follow the commander's orders.
(3) Evacuation speed

In the incidents, due to the fear, one aspect the people were eager to evacuate to a safe place as soon as possible, other aspect they were in a state that want to run more fast, but they did not run, only stay in place. Evacuation speed was listed in Table 7. The results showed that 8.2% of the total occupant evacuation speed was normal, 1-2 times faster than normal populations accounted for 72.8%, slower than the normal 19% of people. Most of the occupant of the evacuation speed were faster than normal speed, in a short time, a large number of people rushed into a certain exit, it was easy to form export plug, a "slow-fast real-time" phenomenon was happen. Therefore, in the evacuation process, it was improtant to guid evacuation, then congestion stampede could be reduce.

Table 7  Evacuation speed distribution

| Evacuation speed                     | Frequency | Percent(%) |
|--------------------------------------|-----------|------------|
| Normal speed                         | 16        | 8.2        |
| 1-2 times faster than normal         | 142       | 72.8       |
| slower than normal                   | 37        | 19         |
| Total                                | 195       | 100        |

(4) Evacuation Behavior

In the evacuation course, leader-following behavior, pushing behavior, queuing behavior, familiarity-following, herding behaviors and return behavior were appeared. The percent of escape behaviors were presented in Fig.2. Fig.2 showed that Leader-following, pushing behaviour and queuing behavior were the most proportion, were 45.9%, 44.4% and 43.1% respectively. The two reasons led to this distributing, one is many people had training experiences, the other is evacuation were guided.
6. Effect Factors on Behaviour

6.1. Escape training and occupant’s sex

The relations of occupant’s psychology state in the evacuation and escape training, occupant’s sex were analyzed by Anova. The p was less 0.05 respectively. These show that escape training and occupant’s sex is evident effect to occupant’s psychology state. The relation of escape training and evacuation behavior were analyzed by Bivariate. Results were listed in Tab.8.

Table 8  The result of Bivariate

|          | Escape training | Evacuation group |
|----------|-----------------|------------------|
| Pearson Correlation | 1 | .234** |
| Sig.(2-ailed) | .001 |   |
| N | 196 | 195 |
| Pearson Correlation | .234** | 1 |
| Sig.(2-tailed) | .001 |   |
| N | 195 | 196 |

The results show that escape training have certain impact to evacuation group.

In the crowd of lose one’s head, the percent of slightly panic crowd was 25%, terribly panic crowd was 75%. At the same time, the crowd of terribly panic were easy to carry herding behavior, the percent exceeding other two psychology was 26% and 22.8%. the proportion of Familiarity following behavior was 27.2%.

6.2. State of psychology

State of psychology of the crowd was obvious effect to evacuation behaviour. It were listed that Nonadaption behaviour of the crowd took in different state of psychology in Table 9. The results showed that terribly panic state was easy to lead nonadaption behaviour. The same behaviour, the proportion of the crowd accounted for terribly panic state was higher, compared the keep clam state the crowd, there was 1.5%, 25.5%, 6.7% and 18.5% difference respectively. Therefore, control the state of psychology is very important to succeed evacuation.

Table 9  Nonadaption behaviour of the crowd took different state of psychology distribution

|                  | Keep clam(%) | Slightly panic(%) | Terribly panic(%) |
|------------------|--------------|-------------------|------------------|
| Lose one’s head  | —            | 0.8               | 1.5              |
| Herding behaviour| 5.8          | 9.0               | 31.3             |
| Pushing behaviour| 11.5         | 7.3               | 18.2             |
| Familiarity-following | 6.7     | 10.4              | 25.2             |

Evacuation speed in different state of psychology were acquired by crosstable in SPSS. The results were listed in Table 10. In terribly panic occupant, It was higher that the proportion of occupant in terribly panic whose evacuation speed was slower than normal than other state of psychology. It was 13.6% and 7.6% difference. In slightly panic occupant, the proportion was higher than keep clam occupant, it was 6% difference. Therefore, It was greater impaction that state of psychology of occupant for evacuation speed.

Table 10  Evacuation speed distribution in different state of psychology by crosstable
7. Statistic Results

Statistic shows that more than half of passengers are unacquainted completely with the fire protection installations in subway, which are mainly affected by their Individual information.

If the Managers guide the evacuation, the number of command-following of the Evacuation managers, accounted for 40-60%. For the people who do not obey the command the five kinds of human behavior in emergencies, including herding, familiarity-following, returning, queuing, and crowding behavior. The proportion of the in front of the three behavior is 10-20% and after two is 20-40%.

Those who are terrible panic is easy to pushing and stampede behavior, while those who have the experienced escape training and those who pay attention to evacuate signage can avoid these non-adaptive behaviors.

8. Statistic Results

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9. Conclusion

(1)The psychology of the crowd affected evacuation, terribly panic was easy to present non-adaptive behavior. If the Managers guide the evacuation, a great number of people keep calmness in china.

(2)Evacuation safety training was effective mean to improve evacuation behavior, and conduced to reduced non-adaptive behavior.

(3)Accurate informations were conducive to reduce pre-evacuation time, controlling emotion of the crowd can decrease non-adaptive.

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References

[1] Jiang C S, Deng Y F, Hu C, Chow W K. Crowding in platform staircases of a subway station in China during rush hours. Safety Science, 2009, 47(7): 931-938

[2] Roh J S, Ryou H S, Park W H, Jang Y J. CFD simulation and assessment of life safety in a subway train fire. Tunnelling and Underground Space Technology, 2009, 24(4): 447-453

[3] Lo S M, Lin P and Huang H C. A review on evacuation modeling. In: Lo S M, Yuen K K, Li W M, eds. Fire Science and Engineering, The 2nd Conference in the Development of Performance-based Fire Code[C]. Hong Kong, 273-290, 2005.

[4] Tian Rong Juan, Study on Human Behavior in Metro Fire and Risk Analysis[D], Guang Zhou University, 2006, 05

[5] Zhao Guang Hua, Study on Application of Pedestrian Simulation in Olympic Subway Station[D], Beijing University of Technology, 2007, 05