Effect of Wording of Fire Warning Announcements on Evacuation Behavior in Subway Stations

(Efecto de la fraseología de los avisos amonestadores del fuego en comportamiento de la evacuación en estaciones del subterráneo)

Ryuzo Ohno, Hidekazu Tamaki, and Masashi Soeda (Department of Built Environment, Tokyo Institute of Technology, Yokohama, Japan)

Generally speaking, fire protection has not been considered as great a priority in subway stations as in other urban public facilities because they are assumed to have fewer fire hazards. However, several major subway disasters have occurred in recent years, such as the fire caused by a suicidal man at a subway station in Taegu, Korea, that took 192 lives in 2003 and the terrorist bombings on the London Underground in 2005. Since people tend to follow the flow of the crowd in emergencies, it is important for them to be led in the appropriate direction in the early stages of evacuation. Although in the case of subways, station staffs are expected to provide this guidance, the number of personnel available in any one place is limited, and those who are on hand may not always be fully informed of the overall situation. One possible solution is to make better use of loudspeaker systems, recent technological advancements in which afford precise control of the area and direction covered by individual units, making it possible to tailor warning announcements to the layout and signs of specific locations in the station.

The present study experimentally examines how the wording of broadcast warning announcements combines with the effects of nearby spatial features and signs to influence evacuation behavior at subway stations. A series of experiments was conducted in an existing Tokyo subway station at five settings, each with a different stair and sign layout. For each session, the subjects (13 male and 8 female university students) were asked to listen twice through headphones to a recorded announcement played over a portable voice recorder, then to start heading in whichever direction they believed safest. Experimenters followed them to record their behavior until they started to go up/down a stair, at which point the subjects were asked why they chose that route.

The following results were obtained by the study: (1) After hearing announcements that do not give any directional instructions, subjects tend to choose their way according to prominent spatial features (most notably upward stairs) and exit signs or, in the absence of such physical cues, to rely on their own behavioral history. (2) Subjects tend to feel uneasy about and sometimes distrust announcements that direct them downstairs, unless the instructions indicate that going downstairs first is necessary to eventually reach the exit. (3) Similarly, when subjects hear an announcement that leads them in the same direction as the location of the fire, they tend to feel uneasy and reluctant unless they are given more details about the situation. These results point to possible problems with recently built or remodeled stations in Tokyo that are designed to have one concentrated ticket area shared by several subway lines of different depths, so that some platforms have only downward stairs leading to the exit. Such unintuitive layouts may result in dangerous confusion for evacuees in an emergency situation.

Emergent Circulation Patterns: Generating movement networks for buildings using stigmergy

Renee Puusepp and Paul S. Coates (Centre for Evolutionary Computing in Architecture, University of East London)

Flocking and optimal path formations are widely explored subfields in agent programming. However, there is no established application of these systems in use in architectural design communities or practices. Most of the work remains highly theoretical and is deployed to analyze existing or planned environments. Besides few examples of generative modeling for architecture, the environmental design processes remain outside the domain of agent studies.

The ongoing research explores the flocking behavior of agents based on the field of vision computation and stigmergic communication. The author tries to employ the emergent behavior of agent colonies into architectural design routines. According to the proposed scenario an agent colony is not solely a passive mechanism to analyze space but can also proactively modify its environment. The work of Bonabeau et al suggests that, given the right set of 'stigmergic' rules,

<extended_abstract>

Effect of Wording of Fire Warning Announcements on Evacuation Behavior in Subway Stations

Ryuzo Ohno[1], Hidekazu Tamaki[1], and Masashi Soeda[1]

[1]Department of Built Environment, Tokyo Institute of Technology
G3-4, 4259 Nagatsuta-cho, Midori-ku, Yokohama, Japan 226-8502
rohno@n.cc.titech.ac.jp

1 Introduction

The new subway lines in central Tokyo run very deep (nearly 50 meters) below ground, and their stations are connected to one another by underground paths that are spatially quite complicated. Passengers must travel long distances from ground level to the platform as well as from station to station, making them susceptible to stress caused by claustrophobia and worries about safety. For this reason, design features of underground pathways have been extensively studied in relation to subjective distance and depth perception (Ohno, 2006). The issue involves not only such psychological factors, however, but also the crucial concern of safety.

Generally speaking, fire protection has not been considered as great a priority in subway stations as in other urban public facilities because they are assumed to have fewer fire hazards. However, several major subway disasters have occurred in recent years, such as the fire caused by a suicidal man at a subway station in Taegu, Korea, that took 192 lives in 2003 and the terrorist bombings on the London Underground in 2005. A subway fire is potentially much more dangerous than those in other structures because 1) the complicated spatial layout causes mass confusion for passengers unfamiliar with the surroundings, 2) smoke and heat not only become trapped inside but flow in the same direction as the evacuation route (i.e., upward), and 3) there are limited access routes both for evacuees to go out and rescue teams to go in.

Since people tend to follow the flow of the crowd in emergencies, it is important for them to be led in the appropriate direction in the early stages of evacuation. Although in the case of subways, station staff are expected to provide this guidance, the number of personnel available in any one place is limited, and those who are on hand may not always be fully informed of the overall situation. One possible solution is to make better use of loudspeaker systems, recent technological advancements in which afford precise control of the area and direction covered by individual units, making it possible to tailor warning announcements to the layout and signs of specific locations in the station.

Given the above, the present study experimentally examines how the wording of broadcast warning announcements combines with the effects of nearby spatial

features and signs to influence evacuation behavior at subway stations. Most previous research on fire evacuation behavior either rely on case studies (e.g., Sime, 1986) or assess building safety performance using computer simulation (e.g., Kakei et al., 2000). Proulx and Sime (1991) conducts experiments to test the effectiveness of verbal evacuation instructions, sharing research interest with this study, but does not take into account the influence of the surrounding physical setting. Thus this study should prove of value both for its use of on-site experiments as well as its attention to specific spatial conditions faced by evacuees in an emergency.

2 Method

A series of experiments was conducted in an existing Tokyo subway station at five settings, each with a different stair and sign layout. For each session, the subjects (13 male and 8 female university students) were asked to listen twice through headphones to a recorded announcement played over a portable voice recorder, then to start heading in whichever direction they believed safest. Experimenters followed them to record their behavior until they started to go up/down a stair, at which point the subjects were asked why they chose that route. To avoid the effects of order as well as of prior familiarity with access routes, the subjects were divided into two groups with the experimental order and the initial paths taken into the settings varied for each.

3 Experiments

3.1 Experiment 1: Fire warning announcements without directional instructions

This experiment examined how spatial features and signs in each of four settings (see fig.1) affected evacuation behavior when subjects heard a warning announcement that did not give any directional instructions ("A fire has broken out. Please evacuate immediately").

Table 1 shows the routes chosen by the subjects and why. The reasons given were classified into three categories: 1) behavioral history, relating to the initial path the subjects took to the experimental setting (e.g., going back the way that they came or, less typically, heading in another direction because they did not remember seeing any exits along the first route), 2) safer-seeming spatial features (e.g., upward stairs, wider- and brighter-looking spaces), and 3) one or more signs indicating a nearby exit. Some subjects mentioned reasons that belonged to two categories.

In setting 1, where upward stairs and exit signs were to be seen on either side—where, in other words, there were almost no asymmetrical spatial features—subjects tended to choose their way according to behavioral history. In setting 2, upward stairs

(C) were chosen by 18 out of the 21 subjects. In setting 3, where there were no upward stairs, 12 subjects chose path (A) based on spatial features and 9 chose downward stairs (C) because signs indicated an exit, but none chose (B). In setting 4, 15 subjects chose upward stairs (A) according to spatial features, while 6 chose path (B) because of the exit sign.

The above results suggest that most subjects chose their evacuation routes systematically according to physical cues in the given situation: spatial features played a prominent role, with upward stairs being preferred over downward ones, while exit signs influenced decisions to some extent.

3.2 Experiment 2: Fire warning announcements with directional instructions

3.2.1 Announcements that direct subjects downstairs

As mentioned earlier, the underground paths connecting stations of different train lines are spatially quite complicated. In some cases, a warning announcement may need to direct passengers downstairs to lead them to the nearest exit. Thus this experiment examined how evacuation behavior was affected when instructions led subjects downward, a direction avoided by almost all of them in the previous experiment. Subjects in group 1 heard the announcement "A fire has broken out. Please proceed to the Ma Line station [one of the names shown on a nearby sign]" at setting 2, and the announcement "A fire has broken out. Please go downstairs first, then proceed to the Ma Line station" at setting 3 (see fig. 1). Group 2 heard the first announcement at setting 3, followed by the second one at setting 2.

As shown in table 2, 15 out of the 21 subjects experienced feelings of uneasiness and resistance when, after hearing the first announcement, they discovered that they had to go downstairs, but the second announcement with additional information warning them that they would be heading downward mitigated such resistant feelings for more than half of them.

3.2.2 Announcements that lead subjects in the same direction as the location of the fire

Station signs typically contain directions for places that are relatively far removed. If a fire is at one of these distant locations, a warning announcement may need to direct passengers partly toward the source of the emergency on the way to the nearest exit. Thus this experiment examined how evacuation behavior was affected when instructions seemingly led subjects toward a dangerous place. Settings 4 (see fig. 1) and 5 (see fig. 2) were used for the experiment. In setting 4, if passengers know that the fire is at the Ch Line station to which route (A) leads, they may also regard route (B) as dangerous because it goes in the same direction as (A) when viewed from the start point of evacuation, although in reality (B) leads to the closest exit. Similarly in setting 5, if the fire is at the Mi Line station some hundred meters away, passengers may avoid route (A) because the sign indicates it leads to the station, although the nearest exit actually lies along the same route, immediately beyond the staircase. Accordingly, subjects in group 2 heard the announcement "A fire has broken out near

the Ch Line station. Please evacuate immediately" at setting 4 and the announcement "A fire has broken out near the Mi Line station. No other places are in danger, so please use the nearest exit to evacuate safely" at setting 5. Group 1 heard the first type of announcement at setting 5, followed by the second type of announcement providing more information at setting 4.

As shown in table 3, 13 out of the 21 subjects experienced feelings of uneasiness and resistance when they heard the first announcement, but only 5 felt the same way upon hearing the second announcement with additional information, which seemed to be successful at mitigating their reluctance.

4 Conclusion

The following results were obtained by the study:

After hearing announcements that do not give any directional instructions, subjects tend to choose their way according to prominent spatial features (most notably upward stairs) and exit signs or, in the absence of such physical cues, to rely on their own behavioral history.

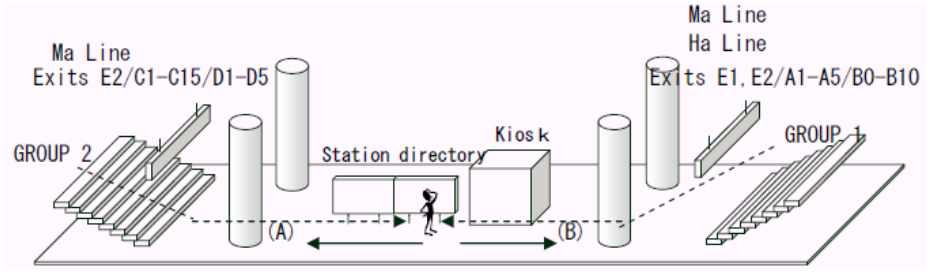
Subjects tend to feel uneasy about and sometimes distrust announcements that direct them downstairs, unless the instructions indicate that going downstairs first is necessary to eventually reach the exit.

Similarly, when subjects hear an announcement that leads them in the same direction as the location of the fire, they tend to feel uneasy and reluctant unless they are given more details about the situation.

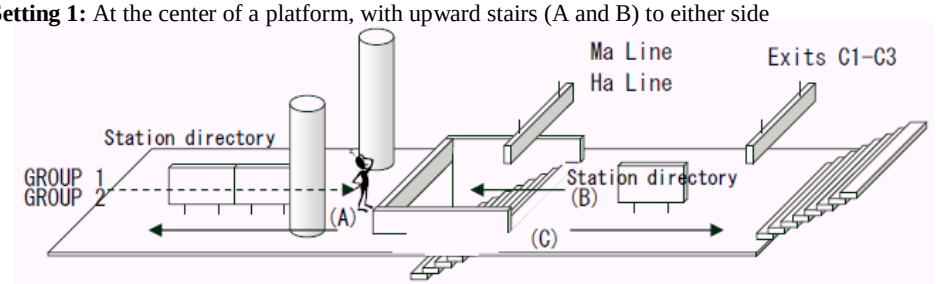
These results point to possible problems with recently built or remodeled stations in Tokyo that are designed to have one concentrated ticket area shared by several subway lines of different depths, so that some platforms have only downward stairs leading to the exit. Such unintuitive layouts may result in dangerous confusion for evacuees in an emergency situation.

References

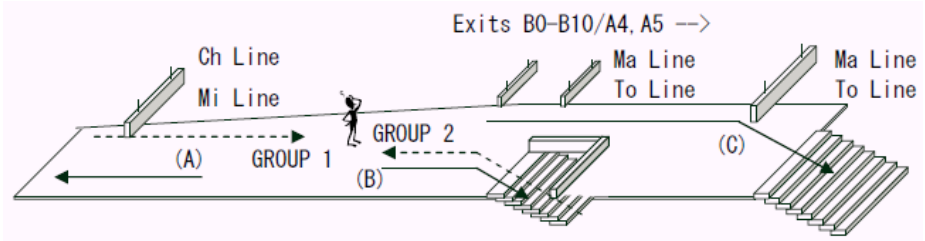
1. Ohno, R.: Passengers' distance/depth perception along underground pathways around subway stations. *Proceedings of the International Academic Conference on Underground Space*, pp. 97-102. Beijing, China (2006).
2. Sime, J.: Mapping people's movements in emergencies: A hotel fire example. *Environments in Transition* (Proceedings of the IAPS 9th International Conference), p.123, Haifa, Israel (1986).
3. Kakei, H., Sato, H., Ibata, Y., and Sako, T.: A psychological study on effectiveness of pre-learning and guide-information in evacuation: A development of evacuation guidance-system based on multimedia technology, part 1. *Journal of Architecture, Planning and Environmental Engineering* (Transactions of the Architectural Institute of Japan) 535, pp. 139-46 (2000).
4. Proulx, G. and Sime, J.: To prevent panic in an underground emergency: Why not tell people the truth? *Fire Safety Science—Proceedings of the Third International Symposium*, pp. 843-852, London: Hemisphere Publishing Corporation (1991).



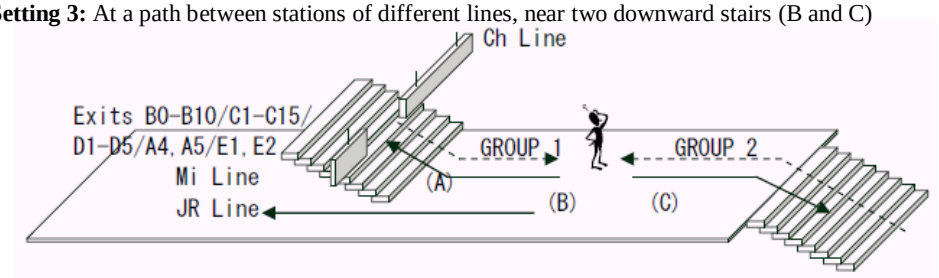
Setting 1: At the center of a platform, with upward stairs (A and B) to either side



Setting 2: At the end of a platform, near both downward (B) and upward (C) stairs



Setting 3: At a path between stations of different lines, near two downward stairs (B and C)



Setting 4: At a path between stations of different lines, near upward (A) and downward (C) stairs

choices ——▶ **initial route into setting** - - - -▶

Fig. 1. Experimental settings 1-4

Table 1. Routes chosen by subjects and why

Subjest		Setting 1		Setting 2		Setting 3		Setting 4	
Group	No.	Choice	Reasons	Choices	Reason	Choices	Reason	Choices	Reason
1	1	(A)		(C)		(C)		(B)	
	2	(B)		(C)		(C)		(B)	
	3	(B)		(C)		(A)		(A)	
	4	(B)		(B)		(C)		(A)	
	5	(B)		(C)		(A)		(A)	
	6	(A)		(A)		(C)		(A)	
	7	(B)		(C)		(A)		(A)	
	8	(B)		(C)		(C)		(A)	
	9	(A)		(C)		(C)		(B)	
	10	(B)		(C)		(A)		(B)	
	11	(A)		(C)		(A)		(A)	
2	12	(A)		(B)		(A)		(A)	
	13	(A)		(C)		(C)		(A)	
	14	(A)		(C)		(A)		(A)	
	15	(A)		(C)		(A)		(A)	
	16	(A)		(C)		(A)		(A)	
	17	(B)		(C)		(A)		(A)	
	18	(B)		(C)		(A)		(B)	
	19	(B)		(C)		(C)		(A)	
	20	(B)		(C)		(C)		(B)	
	21	(B)		(C)		(A)		(A)	

behavioral history spatial features signs

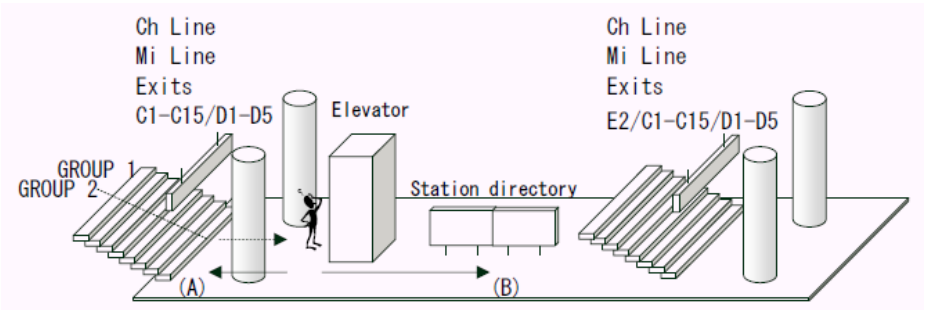


Fig.2. Experimental setting 5

Table 2. Subjects' responses to announcements that direct them downstairs

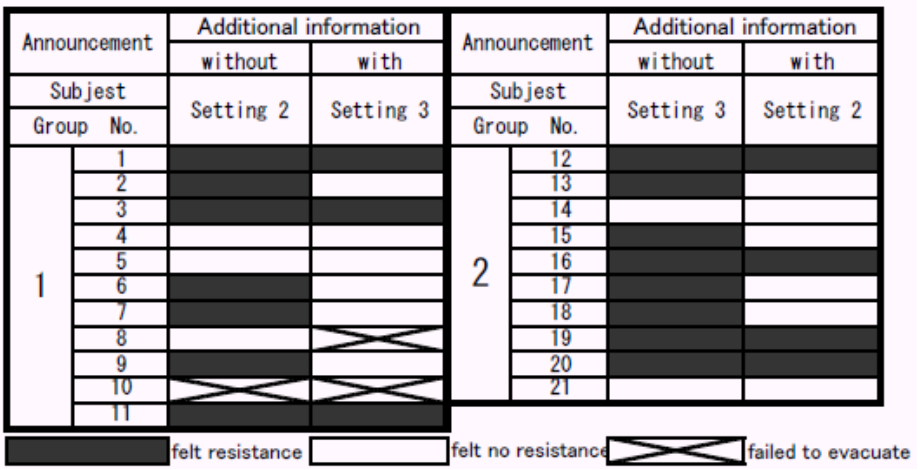


Table 3. Subjects' responses to announcements that lead them in the same direction as the location of the fire