Pedestrians' Mental State and Path Choice at Urban Intersections

Authors:

Teruyuki Isagawa

Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology Research Fellow of the Japan Society for the Promotion of Science

Ryuzo Ohno

Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology

Keywords:

mental state; path choice; demanded information; environmental cue; obtained information

Abstract

People behave according to incoming information from the environment, which is selected consciously or unconsciously based on one's mental state. Many researchers have discussed pedestrians' path choice behavior in a certain situation such as an emergency, while exploring, etc. However, previous research has focused on a specific situation. Therefore, it is unclear how the mental state in a certain situation influences pedestrians' path choice.

Herein we examine the influence of three different mental states, which are defined by the degree of urgency and consequence: urgent, resolute, and recreational. We conducted an experiment using a visual simulation system to present a scene of a Y-shaped intersection, and asked the subject to choose a path. The stimuli were video images of 10 intersections selected from streets in Tokyo. Each video image was created by a series of photos taken at consecutive vantage points toward the intersection by a digital camera with a fish-eye lens. A virtual street was created inside a visual simulation laboratory using images projected on three screens (each 2.0 meters \times 1.8 meters), which span a wide visual field. In the experiment, 32 subjects were asked to imagine that he/she was in the following four different scenarios: 1) "evacuation from a fire and smoke" (urgent state), 2) "searching for a fast-food shop" and 3) "searching for a nearby station" (resolute states), and 4) "strolling without a specific purpose" (recreational state). They were then asked to choose either the left or right route at 10 intersections for each scenario. After each choice, the subjects were asked the reason for their selection.

Path choice preference significantly varied with the situation, i.e., the mental state. A total of 1240 reasons were given, and these were categorized into three groups based on relevant phases. In the first phase, subjects demanded information such as safety, schema of a specific place, novelty. Then they tried to search for environmental cues to meet their needs such as street width, slopes, and signs in the second phase, while in the third phase information was obtained from environmental cues such as spaciousness, liveliness, mystery, and the perception of following the main route. The results indicated that subjects demand distinctly different information according to the situation. Hence, one environment can provide different information depending on the mental state of the subject as he/she searches for environmental cues.

1. Introduction

Human behavior in urban spaces is inherently influenced by the immediate situation. Passini (1984) has mentioned that decision making may differ depending on the conditions, and used three characteristic descriptors to define the situation: emergency, resolute, and recreational. When a person chooses a path at an unfamiliar intersection, his/her preference should vary in accordance with the urgency and consequence of the choice. Although many researchers have discussed pedestrians' path choice behavior in a certain situation such as an evacuation from a fire (Hayashi et al., 1997; Ohno et al., 2009) and exploring (Zacharias, 1997; Sueshige and Morozumi, 2007), the situation has not been treated as a variable.

Typically, people control consciously or unconsciously their behavior using information from the environment. When one walks in an unfamiliar urban space and reaches a decision point, the path chosen depends on the available information from the local environment (Sueshige and Morozumi, 2007). The model of perception offered by Neisser (1976) suggests that people prepare the mind for perception based on a set of anticipatory schemata. When a person extracts information necessary to make a decision from the environment, the content of this information may vary according to the mental state.

This study aims to clarify the relationship between mental state due to a given situation and path choice behavior. Specifically, we aim to elucidate how the mental state of a pedestrian affects route preference and what type of information is extracted from the environment. This knowledge will aid in the design of urban spaces in which diverse situations must be considered to provide useful information.

2. Methods

2.1 Experimental Settings

A path choice experiment was conducted on a virtual street created inside a visual simulation laboratory. Because conditions for a real urban street constantly change with time, weather, and human activities, it is difficult to conduct an experiment under the same conditions. Furthermore, we wanted to test various visual features of the surrounding environment effectively. Although questions about whether path choices in a virtual street and a real environment are similar may arise, Zacharias (2006) has argued this point when he dealt with a path choice experiment in an underground walking system. He concluded that although some choice motivations like people, sounds, and smells are not parallel, the choices in the two environments do not statistically differ.

Initially we selected 10 Y-shaped intersections from the streets in Tokyo (Figure 1) with varying physical features such as street width, number of signs, etc. Then a digital camera (Nikon D3S) equipped with a 16-mm fish-eye lens (180 degrees, 4256×2832 pixels) was used to acquire a series of daytime photographs. At each site, we took between 28 and 48 photos at consecutive vantage points by moving stepwise toward the joint of intersection (Figure 2). A video image was created by changing the photos at one second intervals, and a virtual street was created inside a visual simulation laboratory using the video images projected on three front screens (each 2.0 meters \times 1.8 meters) that covered a wide visual field (Figure 3).

Herein we consider three types of mental states that differ in urgency and consequence; from high to low, they are urgent, resolute, and recreational states. We prepared four scenarios to set concrete situations, which evoke various mental states. Because we hypothesized that path choice behavior in the resolute state may differ according

to the objective facilities, we prepared two scenarios.

The urgent state scenario is depicted by:

(1) "A fire is nearby and smoke is behind you."

There are two scenarios for the resolute state:

(2) "You feel very hungry, and are searching for a fast-food shop."

(3) "While you are shopping, you get lost. You want to go back to a nearby station."

The recreational state scenario is indicated by:

(4) "You are strolling without a specific purpose. Time is on your side."

2.2 Procedure

Thirty-two subjects (21 male and 11 female university students) were asked to imagine each scenario, and choose one of the two routes (left or right) at each intersection. Additionally, subjects were asked to envision that they arrived at a place for the first time and walked along the streets by themselves. After making each choice, the participants were asked the reason for their selection and whether they had difficulty making a decision. All the responses were recorded and transcribed. Each subject was required to make 40 choices (10 intersections \times 4 situations), which took 70–90 minutes. The order of the experimental sessions was counterbalanced across the subjects.

Based on the interviews conducted at the end of the experiment, data obtained under the following two circumstances were omitted from the analysis. One is when the subject had been to a site, and the choice was made based on previous knowledge. The other is when the route selected allowed the subject to directly enter a shop. Thus, 1240 cases were analyzed.

(Insert Figures 1, 2, and 3)

3. Results and discussion

3.1 Path choice tendencies

Figure 1 shows the overall results with 1240 choices. The graphs indicated that path choice tendencies vary according to the situation. As an example, all subjects preferred the left route at intersection 7 for the situation of "evacuation from a fire and smoke", whereas 80% (25 out of the 31 subjects) preferred the right route for the "searching for a fast-food shop" scenario. The results of Cochran's Q test confirmed that preference in path choice varied significantly at all intersections, depending on the situation (i.e., the mental state). The significance levels were p<0.05 at intersection 1 and p<0.01 at the other intersections.

Table 1 shows the number of times that the subjects had difficulty judging at each intersection. Judgment difficulties were mentioned 162 times (13% of the time). Although we expected that the difficulty would vary according to the scenario, the results do not necessarily confirm this. However, the subjects indicated difficulty more often (67 times, 41%) at intersection 8, which was intentionally selected because the physical environmental features on both side routes were similar. Among the four scenarios at this intersection, fewer subjects expressed

judgment difficulties for the situation of "strolling without a specific purpose". In the post interviews, the subjects mentioned an unusually designed house on the right attracted their attention at intersection 8.

(Insert Table 1)

3.2 Environmental information used to decide

To detect the environmental information used to make a choice, the comments at each intersection were analyzed. These comments were initially classified according to relevant phases based on our hypothesis of how people perceive the environment: "Demanded information", "Environmental cue", and "Obtained information". In the first phase, people demand information to make an appropriate choice such as safety, schema on a specific place, and novelty. In the second phase, cues from the environment are consciously or unconsciously obtained; that is, characteristic features such as street width, slopes, and signs are derived. In the third phase, information from environmental cues such as spaciousness, liveliness, mystery, and the main route is gathered. When an individual subject mentioned more than one aspect, each aspect was counted separately.

Consequently, we found that the information from the environment varied according to the situation. Figure 4 shows the frequency of demanded information for each situation. For "evacuation from a fire and smoke", nearly 60% of the choices were made for the sake of safety and 30% were due to relief. For the situation "searching for a fast-food shop or a nearby station", place schema, which are established by previous experiences, were frequently mentioned (nearly 90% for the fast-food case and more than 70% at station case). For example, the location of a station was judged based on stereotypes associated with street width and the presence of other people. For the scenario of "strolling without a specific purpose", novelty (60%) and pleasantness (15%) were demanded.

Although environmental cues varied at each intersection, they could be roughly divided into two types according to the size that appeared in the visual field. One was a "spatial cue", which is related to three-dimensional features of the environment such as street width, unbroken vista, density of the building, and slopes. The other was an "elemental cue", which is related to elemental features scattered around the environment such as specific shops, signs, trees, other pedestrians, and cars. Figure 5 shows the frequency of these types of the cues for each situation. Interestingly, for the situation of "evacuation from a fire and smoke", about 90% of the cues were spatial, whereas the situations of "searching for a fast-food shop" and "strolling without a specific purpose", the percentages of spatial and elemental cues were almost same. These observations suggest that even in the same space, the perceived environment differs according to the mental state. When a person is in an urgent or serious mental state, "spatial cues" provide a rough impression of the overall environment, whereas for a person in a recreational state or searching for a specific shop, details or some characteristic components of the environment are more important.

Figure 6 shows the frequency of the main "obtained information" for each situation. Spaciousness (32%), path direction (23%), and legibility (15%) were often cited for the situation of "evacuation from a fire and smoke", while the perception of following the main route (more than 25%), and liveliness (more than 10%) were often obtained for the situations of "searching for a fast-food shop or a nearby station", and mystery and liveliness were frequently (about 16%) supplied for the situation of "strolling without a specific purpose".

Because we prepared two situations as a resolute state, we probed the similarities and differences of choice

preferences and usage of environmental information between the situation of "searching for a fast-food shop" and "searching for a nearby station". We performed multiple comparisons for choice preferences for each situation using binomial tests with a Bonferroni correction. The significance levels were set at p<0.05. Only two of the 10 intersections (intersections 3 and 7) had significant differences. The usage of environmental information was very similar for these two; the main demanded information was place schema, and the main obtained information was liveliness and the perception of following the main route. However, for the station case, some choices were attributed to the ease of asking someone or consulting a map (i.e., acquiring information efficiently) (See Figure 4). Thus, when searching for a popular facility such as station, people may use different sources of information.

(Insert Figures 4, 5, and 6)

Finally, we evaluated the relationships between demanded information, environmental cues, and obtained information. Figure 7 shows network models for the four measures of demanded information selected from Figure 4 where the line width denotes the strength of the connection. When safety was demanded, 60% obtained spaciousness from the street width or the density of the buildings (Figure 7(a)). For the schema about a fast-food shop, the perception of following the main route, and liveliness were highly connected (both about 30%). The perception of following the main route mainly came from street width, whereas liveliness was due to signs, shops, and the presence of other people (Figure 7(b)). For the schema about a station, the main obtained information was from the perception of following the main route (about 35%), which was determined from both street width and the number of cars (Figure 7(c)). As for novelty, liveliness and mystery were highly connected (both about 30%). Liveliness was associated with the presence of shops, other people, and signs. Mystery was connected with an unbroken vista or the presence of slopes (Figure 7(d)). Interestingly, novelty was sometimes connected with a sense of a sub-trail, which was associated with street width and the number of cars.

(Insert Figure 7)

3.3 Subject's individual differences in path choice

Even in the same situation, individual subjects chose different paths in some cases. We examined the cause of this, and found different choices in the same situation could be explained by the information gained from the surrounding environment.

For example, at intersection 1, most of the subjects demanded information related to place schema for the situation of "searching for a fast-food shop", and used shops or signs as environmental cues. However, the subjects were divided into two large groups (left: 14; right: 17). Comparing the obtained information, those who chose the right tended to obtain information associated with liveliness, and judged based on the number of shops and signs, whereas those who choose the left detected information such as the type of shops on the right path were not compatible with fast-food shops such as drugstores and pubs (Figure 8). At intersection 2 for the situation of "strolling without a specific purpose", novelty was the most demanded for both of the subject groups regardless if the left or right path was selected. However, the content of the obtained information and environmental cues

differed; those who felt mystery from the slope chose the left, while those who felt liveliness due to the number of shops and signs chose the right (Figure 9).

(Insert Figures 8 and 9)

Figure 10 plots the results of the subject's choices that are in the major group at each intersection for each situation. The distance from the bottom line (50%) indicates the inclination of the choice. Comparing the mean value of the choice for each situation, the inclination for the situation of "strolling without a specific purpose" (15%) was much smaller than the other situations (around 30%). Hence, we conclude that for the strolling situation, choice is based on individual preference instead of physical features near the intersection.

(Insert Figure 10)

The above discussion demonstrates that environmental cues can be interpreted in multiple ways according to the situation or individual. For example, street width was strongly related to safety due to spaciousness, whereas width became an important cue for place schema and relief through the perception of following the main route. Furthermore, width was even related to novelty by the sense of a sub-trail. Although the former two were preferences for a wider path, the latter was for a narrower path. In regard to slopes, going uphill was related to body load, and often rejected, except in the strolling situation where hills were selected because they were associated with mystery.

4. Conclusions

Herein pedestrians' preferences between two routes in an urban Y-shaped intersection under a certain mental state are examined, and the relationship between choice and usage of environmental information is discussed. Choice tendencies, which are affected by mental state, significantly differ by situation. Furthermore, most of the differences can be explained by environmental information used to make a decision. When people evacuate from a fire and smoke, safety and relief are priorities, whereas place schema is predominant when searching for a fast-food shop or nearby station. However, when strolling without a specific purpose, novelty and pleasantness are often demanded. Moreover, the type of environmental cue varies according to the situation. To evacuate from a fire and smoke, most choices are made using spatial cues, but when searching or strolling, both spatial and elemental cues are employed. Finally, information obtained from environmental cues also depends on the situation. For fire and smoke, spaciousness and path direction are often obtained, whereas liveliness and the perception of following the main route are gained when searching for a fast-food shop or a station. For strolling, mystery and liveliness are often obtained.

In some cases, particularly for strolling, the choices can be divided into two large groups, which are thought to reflect preferences of the individual. However, the individual choice can be largely explained using the different information derived from the environment. Moreover, our results demonstrate that each environmental cue can have multiple meanings. For example, slopes are connected to both body load, which discourages a choice, and

mystery, which encourages a choice.

Our results suggest that even in the same place, the perceived environment may differ drastically according to one's mental state. However, behavioral differences remain unclear because the discussion herein depends mainly on the analysis of the subjects' protocol. Regardless, these facts confirm that the relationship between human activity and physical environment is flexible. Obviously, urban spaces should be designed considering diverse situations and various people. Physical environments should be developed so that useful information can be gained at anytime. In other words, the environment should support the ability to make a proper choice.

Because the present study employs pictures of real urban intersections, controlling the individual physical features that might be picked up as environmental cues within the local environment may be difficult. Hence, a future study should examine the effect of each environmental cue as well as clarify the mechanism of how the physical environment influences human perception, decision-making, and behavior.

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Figure 1: Intersections and path choices



Figure 2: Partial pictures presented in our experiment (Intersection 4)



Figure 3: Visual simulation device

Table 1: Number of cases where subjects indicated difficulty deciding

	intersection										tatal
	1	2	3	4	5	6	7	8	9	10	totai
fire & smoke	4	2	4	1	5	3	3	16	5	2	45
fast-food	3	0	0	4	1	3	0	24	7	5	47
station	1	2	3	3	1	2	8	18	3	1	42
strolling	1	1	2	1	2	3	0	9	6	3	28



Figure 4: Demanded information for each scenario







Figure 6: Obtained information for each scenario



Figure 7: Network models of environmental information to measure demanded information







Figure 9: Environmental information and path choice results (intersection 2, strolling)



Figure 10: Percentage of subjects who selected the majority path choice