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Factors Affecting Emergency Evacuation: Floor Plan Cognition and Distance

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Abstract: People tend to take their spatial cognition and wayfinding behaviors for granted while moving about in familiar spaces or traversing regular routes (e.g., the way to work). However, when an emergency occurs, even if people evacuate from a familiar venue, they are still likely to experience unexpected and irreparable tragedy. This study conducted an on-site experiment and a survey investigation. First-person view (FPV) floor plans were adopted to develop a relevant experiment, which was then used to investigate the relationship between wayfinding behavior and two influencing factors: floor plan cognition and distance. The *t*-tests for the accompanying questionnaire indicated that women (31%) are better than men (5.3%) in legend recognition and men (25.5%) outperform women (7.1%) in orientation; both findings achieved significance and are consistent with the results of previous studies conducted by neuroscientists. One-way ANOVA showed that when participants read a floor plan that was difficult to understand (not FPV), they took considerably more time (153.82 s) to reach the closer staircase than those who read a floor plan that was easy to understand and headed to the farther staircase (113.40 s). The understandability of floor plans is key to affecting the public's evacuation time.

Keywords: wayfinding; behavior; legend; recognition; orientation; floor plan; distance; cognition; emergency; evacuation

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1. Introduction

Most people are unfamiliar with large buildings and venues of complicated partitions and interior decorations except employees familiar with the building layout for work reasons. Those employees can fully grasp the number and layout of rooms, evacuation paths, emergency exits, and the optimal evacuation paths in the event of various disasters.

The evacuees cannot tell or ignore directions for evacuation due to the following reasons:

(1) Unfamiliarity with the building: Occupants usually evacuate using familiar routes [1]. Most people need to spend time finding the evacuation route because they are unfamiliar with the building [2].
(2) Unclear signage of evacuation routes: Clear signage can help evacuees find the directions and shorten evacuation time. Experiments showed that the factors affecting the clearness of signage include: sign area, stroke thickness, bounding area of words, the luminance of characters, contrast, color, orientation, the visual environment surrounding the sign, transparent background, and the word spacing ratio [3,4].
(3) Absence of conspicuous legends to assist the public in evacuation: the buildings' newcomers rely on the legends or location marking to find a way out easily [5].

(4) Visual access: when smoke accumulates or the light is off, it is harder for the evacuee to find the way out [5].
(5) Backing-homing instinct: Chiewchengchol et al. [6] concluded that 50% opted for back-homing during a fire, while the rest sought a new evacuation direction. Back-homing is defined as "the behavior in which an evacuee who is not familiar with a building structure or has entered it for the first time tracks the route by which he/she entered".

Every day, people engage in a variety of indoor and outdoor activities. People tend to take for granted their spatial cognition and wayfinding behaviors while moving about in familiar spaces (e.g., residence) or traversing regular routes (e.g., the way to work). However, when a disaster occurs, even if people take emergency evacuation actions to escape a familiar venue, they are still likely to experience unexpected and irreparable tragedy.

In contrast with the previous case, when people experience a disaster in an unfamiliar venue, they are relatively harder to analyze the situation, recognize hazards (validation period), judge danger (decision-making period), and take action (movement period) [2,7–9]. If they are scared, feared, or helpless, they may take more time to decide for evacuation. Therefore, competent authorities and the public must investigate how to implement appropriate facility design and equipment and develop easy, understandable, and user-friendly aids to enhance people's spatial cognition abilities to quickly identify the correct evacuation path. Thus, it can prevent delayed actions or missing the possible evacuation routes.

A floor plan is a vital tool for obtaining spatial information. To achieve proper functionality, the design of a floor plan should present correct content and employ functional elements, such as legends, orientation, distances between areas, and other spatial information (e.g., names of areas) to assist users in understanding its content.

Floor plans are available for use at any time and in venues. However, individual differences in spatial cognition ability result in various degrees of understanding various floor plans. Even when reading the same floor plan, the degree to which people understand the plan varies by gender and individual spatial cognition ability [10]. McGuinness and Sparks [11] experimented with sketch map tasks for men and women. They argued that men are more aware of routes and connectors, but women are more aware of landmarks (legend). Galea and Kimura [12] investigated sex differences for route-learning. It was found that men took fewer trials to reach the criterion. Accordingly, the gender difference in wayfinding behavior is an essential research topic.

This study conducted an on-site experiment and a survey investigation to explore the gender difference in legend recognition and orientation. Floor plans were adopted to develop a relevant experiment that was then used to investigate the relationship between wayfinding behavior and two influencing factors: floor plan cognition and distance.

Most people, and even some relevant government authorities, consider the floor plan depicting the emergency evacuation route less important than fire protection facilities and fire-fighting equipment. However, a basic floor plan can be beneficial in times of need. Negligence concerning providing floor plans often causes severe casualties and property loss, as described in the White Snow Hotel fire (seven deaths) [13]. If the people involved in this case recognized the importance of floor plans in advance and the government and supervising agencies would have updated or improved the floor plans properly, the number of people that died in the fires would have been considerably lower [14].

Numerous scholars conducted multifaceted and in-depth investigations on spatial cognition and wayfinding behavior. Souman et al. [15] indicated that the signals sent from the vestibular system control balance and movement sensors of muscles and joints. When people's eyes are covered, the brain has difficulty constructing a straight line due to limited information to construct a virtual one; consequently, people often deviate from their intended direction and walk in circles. Cheng and Newcombe [16] determined that spatial cognition behavior is affected by spatial geometry information, spatial legend information, language, age, and whether they are inside or outside space. Hart and Moore [17] defined spatial cognition as the ability to construct a spatial relationship. Spatial cognition is the process through which people store, understand, and recombine stimulations from the environment. This process relates to physical elements in space and symbolic meanings, environmental events, and the interactive affection between individuals and groups.

Wiener et al. [18] proposed a classification system for human wayfinding tasks, which is based on the knowledge necessary to execute them. The study emphasized the significance of taking cognitive factors into account when analyzing wayfinding behavior. The researchers described maps, signage, route instructions, and similar tools as "aided wayfinding". When using a map for wayfinding, other cognitive processes, such as symbol identification, object rotation, self-localization, and establishing a connection between the map's allocentric perspective and the egocentric perspective experienced while navigating the environment, play vital roles [19].

Numerous factors influence spatial cognition, and they can be grouped into two categories: (1) personal factors such as age, gender, and experience (i.e., familiarity with space or the surroundings); and (2) physical and environmental factors such as the spatial plan and design [20]. Therefore, inappropriately designed space can impede spatial cognition. Golledge [21] contended that when constructing a route to a destination, people first determine how to connect the space they are in with their destination. This creates the spatial structure in their mind, which involves orientation, distance calculation, and absorption of relevant information as a reference for moving to the destination. If the distance is too far or the direction cannot be readily determined, people will likely change their minds and abort their departure plans. Such a process of recognition and decision-making refers to as wayfinding. Raubal and Eegenhofer [5] stated that wayfinding's goal is to find a path from the original space to another space. Therefore, the result of wayfinding is also a crucial reference factor for evacuation.

In the literature concerning the effect of legends on cognition, Kaplan and Kaplan [22] claimed that individuals often regard the featured places as the most references when moving through space. Golledge [21] noted that featured places serve as identifying features in the movement process. In other words, the brain constructs and organizes legend information. For example, suppose no prominent featured places exist on the path to a destination. In that case, people search neighboring areas of the destination to find notable, easily recognizable, and memorable places with legends on the map. Siegel and White [23] stated that people often use featured places as reference coordinates in moving to a destination, mainly to find their way on the path. Allen [24] indicated that individuals' wayfinding behavior differs according to their purpose for visiting the destination in the wayfinding process. Therefore, adopting various wayfinding behaviors can lead to various wayfinding results.

When using a map for navigation, most people prefer that the top direction of the map aligns with the viewer's facing direction. If an inverted map is used, where the facing direction corresponds to the bottom of the map, it becomes more difficult to understand. This can lead to the viewer taking the wrong direction, a phenomenon referred to as the "alignment effect" [25–27].

The standard ISO 23601:2020 provides guidelines for designing and utilizing escape and evacuation plan signs in public buildings and facilities. The standard specifies the design, shape, color, and content of these signs, which are crucial for ensuring the safety of occupants during emergencies. In addition, the standard emphasizes orienting the escape plan according to the viewer's position. Therefore, that enhances its legibility and comprehensibility [28].

BS 9999:2017 is a British standard for fire safety in the design, management, and use of buildings. It provides a risk-based approach to fire safety engineering and sets out guidelines for achieving a reasonable level of fire safety for all types of buildings, except for individual private dwellings. The standard covers various aspects of fire safety, including evacuation plans, which are crucial for ensuring the safe and efficient evacuation of occupants in case of an emergency. Evacuation plans play a vital role in fire safety as they help occupants quickly and safely exit the building during emergencies. According to BS

9999, these plans must be well-documented and include clear diagrams and escape routes. Diagrams should be easy to read and understand, displaying crucial information such as the location of exits, fire-fighting equipment, and emergency assembly points. Escape routes must be designed with proper signage, sufficient width, and minimal obstructions to ensure a smooth evacuation process. Moreover, BS 9999 emphasizes the importance of regular drills, training, and maintenance of evacuation plans to ensure their effectiveness and to keep occupants well-informed about the correct procedures to follow during an emergency [29].

Both standards state the importance of easy-reading evacuation diagrams. ISO 23601:2020 emphasize the importance of "the escape plan according to the viewer's position". Furthermore, it implies decreasing the time for finding the way out from the plan.

Research emphasizes the crucial role of effective emergency signage in promoting efficient evacuations during emergencies. Guo et al. [30] examined the impact of emergency signage on building evacuation behavior through experimental research, finding that clear, visible, and strategically placed emergency signs substantially enhance evacuation efficiency. Ozel [31] discovered that time pressure and stress can negatively influence evacuation behaviors, underlining the importance of easily accessible and comprehensible emergency signage.

Guo et al. [30] introduced an evacuation model that considers the phototactic behavior of panic pedestrians in situations with limited visibility, such as during an emergency. Their findings highlight the significant impact of phototactic behavior on the evacuation process, suggesting that it should be considered for more accurate evacuation simulations and planning. In a related study, Zhang et al. [32] investigated the evacuation performance of pedestrians in a three-lane urban tunnel with natural ventilation during a fire scenario. They found that the tunnel's lane layout and natural ventilation system substantially affected evacuation efficiency. These studies emphasized the importance of considering phototropism, or the tendency to move towards light, in both pedestrian behavior and infrastructure design to improve the effectiveness of evacuation systems in low-visibility conditions, such as during fires or other emergencies.

In other words, people adopt various wayfinding behaviors depending on their purposes, and the behaviors then affect their wayfinding results. Spatial cognition can help people solve spatial problems. In summary, spatial cognition refers to how people learn, memorize, compile, and reorganize all information after receiving stimulations from other people or objects in the environment. It entails eventually formulating the decision in the brain [22]. Cognitive behavior research encompasses studies on cognition, behavior, the neural center, and responsive behavior [33]. Research of wayfinding behavior often adopts tools such as virtual reality, floor plans, perspectives, and legends. In-depth investigations were also conducted on hospitals and tourist areas [34,35].

Upon perceiving guidance, crowd behavior during high-rise building emergency evacuations encompasses leader–follower and herding behaviors in the early stages of evacuation. Initially, crowds tend to hesitate in reacting to danger, waiting for others to act, a phenomenon known as "leader–follower behavior" [36]. Ding and Sun [37] found similar results. Herding behavior refers to individuals in high-pressure situations who become influenced by group actions and abandon their personal views to conform to the majority behavior [36]. Lin et al. [38] conducted experiments in three cities, demonstrating that uneven crowd flow distribution encouraged participants under mental stress to follow the majority, supporting the herding behavior notion. Chen et al. [39] discovered that people exhibited a herding tendency when deciding to evacuate. Furthermore, individuals were inclined to select the exit they frequently used for escape due to their daily habits.

In the Building Design and Construction section of the Regulations Regarding Construction Techniques [40], Article 90 stipulates that "an evacuation floor should have at least two exits in different directions at appropriate locations". Articles 93–96 and Article 107 describe regulations on walking distance. Article 241 in Section 3, Fire Protection and Emergency Facilities, of Chapter 12, Tall Buildings, mandates that "tall buildings should install at least two special emergency staircases that accord with the bidirectional evacuation principles". The article indicates that if the fire is containable, people should extinguish it quickly. Additionally, if the fire cannot be extinguished quickly, the top priority is escaping the on-fire floor and entering the staircase. Additionally, a minimal walking distance is set to ensure people can quickly enter safe areas. If the floor plan is transparent, evacuees easily find a way to reach evacuation floors.

In this study, we conducted an onsite experiment for wayfinding behavior using floor-plans. Additionally, a questionnaire was adopted for investigation of the orientation and legend of men and women. The following sections include the materials and methods adopted in this study, results, and conclusions.

The highlights of this study are listed below:

1. An on-site experiment assessed legend recognition and orientation abilities during an evacuation scenario;
2. The study found that consistency between floor plan presentation and the actual site's physical layout significantly impacted participants' cognitive abilities;
3. First-person perspective floor plans were found to be the most easily understandable and recognizable;
4. Statistical analysis using *t*-tests revealed:
    - Women (31%) outperformed men (5.3%) in legend recognition;
    - Men (25.5%) surpassed women (7.1%) in orientation tasks;
    - These findings align with prior research in neuroscience.
5. One-way ANOVA analysis highlighted:
    - Differences in average time taken by participants when faced with varying combinations of easy/hard-to-read floor plans and closer/farther designated staircases;
    - Hard-to-read floor plan and farther designated staircase resulted in the longest time taken;
    - Easy-to-read floor plan and closer designated staircase led to the shortest time;
    - The study found that participants with difficult-to-understand floor plans took considerably more time to reach the closer staircase.
6. Floor plan readability plays a more critical role when the distance between staircases is shorter. This emphasizes the importance of clear, comprehensible maps during emergency situations.

2. Materials and Methods

2.1. On-Site Experiments

On-site experiments were conducted to determine if the first-person-view floor plan could save some time for the evacuees to find the exits. In addition, the investigations of the influences of distance and the difficulty level of image cognition on wayfinding behavior were also explored. Finally, a questionnaire was conducted to investigate the difference between men and women in legend recognition and orientation abilities. Experimental procedures are described as follows:

1. All participants were new to this site. The participants were guided to the starting point through staircase A (Figure 1), near the starting point. In this setting, the participants only relied on the floor plan to find the designated staircases later.
2. Create two floor plans, Plan A and Plan B, for the selected venue.
3. Figure 1 presents Floor Plan A and Floor Plan B. Floor Plan A was created using the first-person view (FPV). Floor Plan B was nearly identical to Floor Plan A. The difference between the two was the location of the "you are here" icon and their hanging position. Floor Plan A was attached to the wall on the right side of the starting point, and Floor Plan B was attached to the wall on the left side of the starting point (Figure 1).

4. The participants selected to read either Floor Plan A or Floor Plan B. After they decided, they drew lots to decide whether to find Staircase I (farther) or Staircase II (nearer).
5. After the participants' finished reading the floor plan on the wall, they were asked to walk to the designated staircase; after reaching the staircase, the participants were asked to return to their starting point (i.e., the starting point was also the destination).
6. A research team member recorded the absolute time at the starting point, the staircase, and the final destination. The items being recorded were the time the participants started reading the floor plan, the time they set out, the time they arrived at the staircase, and the time they returned to the destination.
7. To simplify the recording procedure and avoid errors, all research team members must adjust their watch or cellphone clock to the national standard time. Thus, the absolute time of the actions mentioned above was recorded.
8. After reaching the destination, the participants were asked to complete a questionnaire on legend recognition and orientation.

The participants could choose to read either Floor Plan A or Floor Plan B. Floor Plan A was easy-to-read because it adopted the FPV floor plan. However, it means that when the participant watched the floor plan, the corresponding actual things were in the same view plane. As for Floor Plan B, the corresponding actual things were on the opposite side of the plan, making the viewer hard-to-read the floor plan.

Moreover, to avoid a situation in which all participants chose the easier task, participants were required to draw lots to decide whether to visit Staircase I (farther) or Staircase II (closer). Because the participants could not know in advance whether they would be assigned to find Staircase I or Staircase II, they needed to read the floor plan carefully.

This study employed four statuses, namely difficulty (D), easy (E), far (F), and close (C), to form combinations and explored the influence of different status combinations on the time the participants spent finding the correct staircase. The four are defined as the following:

(a) Reading easily understandable Floor Plan A (abbreviated as (E) hereafter);
(b) Reading the relatively difficult Floor Plan B (abbreviated as (D) hereafter);
(c) Being assigned to Staircase I, which is farther from the starting point (abbreviated as (F) hereafter);
(d) Being assigned to Staircase II is closer to the starting point (abbreviated as (C) hereafter).

Table 1 shows the combinations of different floor plans and staircases. The easy-to-read floor plan (E) adopted FPV, which means the map coincided with the surroundings of the environment. In contrast, in the relatively difficult-to-read floor plan (D), the layout was on the opposite side of the viewer.

Table 1. Combinations of onsite experiment.

Floor Plan / Staircase	E (Easy-to-Read Floor Plan)	D (Relatively Difficult-to-Read Plan)
F (farther staircase)	EF	DF
C (closer staircase)	EC	DC

The combination of DF consisted of the longer route and a relatively difficult-to-read map. The combination of EC consists of a shorter route and an easy-to-read floor plan. The experiment examined whether the evacuees completed the evacuation took less time using an FPV floor plan.

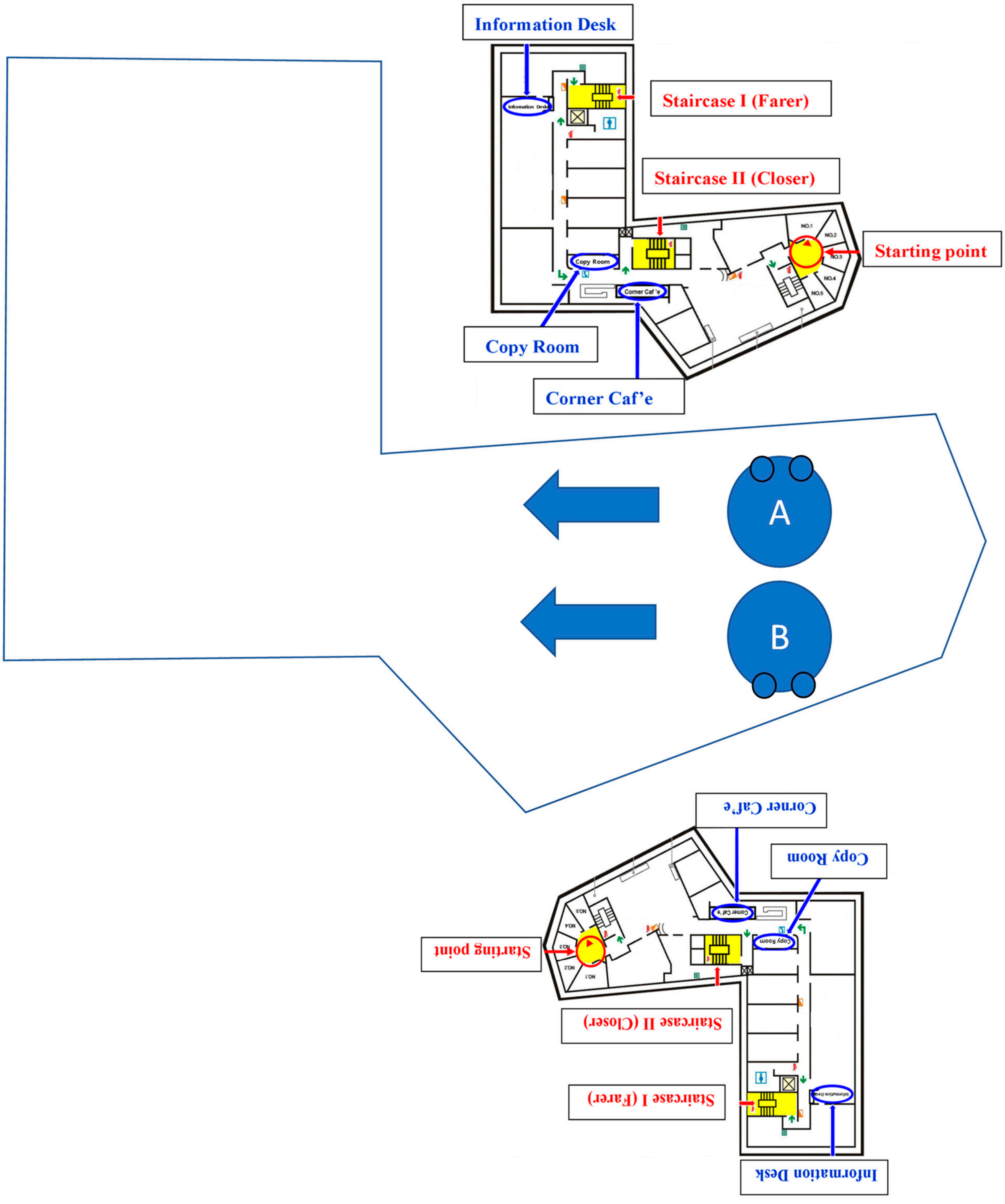

Figure 1. Schematic floor plans attached to the corridor wall in the onsite experiment.

2.2. Questionnaire Survey for the Gender Difference

This study conducted a questionnaire survey to assess the participants' legend recognition and orientation abilities. The results were analyzed to determine differences in the participants' psychological perceptions. In addition, during clustering analysis, questionnaire survey data were used to discuss the correlation between wayfinding behavior and image cognition.

A total of 196 people participated in this on-site experiment. After eliminating 18 participants who did not complete the questionnaire survey or the on-site experiment, 178 valid samples were obtained. The valid samples were received from 94 men (52.80%) and 84 women (47.20%).

The questions and scoring standards are described below.

1. What is your impression of the spatial layout after reading the floor plan in the corridor? (Please select one answer only)
   (A) I have absolutely no idea where the copy room, Corner Café, and the information desk are located.
   (B) I roughly know the location of the copy room, but I am not certain.
   (C) I know the location of the copy room and Corner Café.
   (D) I know the locations of the copy room, Corner Café, and the information desk.
   (E) I know the locations of the copy room, Corner Café, and the information desk. I also know that Staircase I is near the information desk, and Staircase II is near the copy room and Corner Café.
2. What is your impression of the spatial layout after reading the floor plan in the corridor? (Please select one answer only)
   (A) I have absolutely no idea what Staircase I and Staircase II's relative locations are or the distance between them.
   (B) I have a rough idea of Staircase I and Staircase II's relative locations and the distance between them, but I am unclear.
   (C) When setting out from the starting point, I pass Staircase II first before arriving at Staircase I.
   (D) When setting out from the starting point, I pass Staircase II first before arriving at Staircase I. On the way to Staircase I or Staircase II, both staircases are on the route's right-hand side.
   (E) The floor plan shows that Staircase I is to the east of the information desk, and Staircase II is to the east of the copy room and the north of Corner Café. The distance between Staircase I and the starting point is more extensive than between Staircase II and the starting point.

Question 1 and Question 2 were identical, but the choices in the two questions were different. Those questions aimed to identify the participants' impressions of the specific landmarks such as Corner Café, copy room, the information desk, Staircase I, and Staircase II.

2.3. Scoring Standards of the Questionnaire Items

The experiment was conducted in the basement to prevent outdoor features such as buildings, plants, or sunshine from serving as characteristic legends. The relationship between this experiment and the adopted Floor Plans A and B was described as follows:

1. Floor Plan A was created using the first-person perspective and attached to the wall on the right side at the starting point. The orientation of Floor Plan A was consistent with the actual layout of the site. In other words, Floor Plan A was a 2D presentation of the 3D layout in the actual site.
2. Floor Plan B was nearly identical to Floor Plan A except that the "you are here" icon was placed in a different location. Floor Plan B was attached to the wall on the left side at the starting point. The Floor Plan B orientation was inverted left and right with the site's actual layout.
3. When completing the questionnaire, the participants were asked to choose only one answer for each item. In consideration of the potential variance in the participants' cognitive abilities, the subjective factor was lowered to the minimum in the design of items. The items were scored according to the standards shown in Table 2.

Table 2. Scoring standards of cognitive abilities.

Item 1		Item 2	
Choice	**Point(s)**	**Choice**	**Point(s)**
A	1 (Poor legend recognition)	A	1 (Poor orientation)
B	2 (Unsatisfactory legend recognition)	B	2 (Unsatisfactory orientation)
C	3 (Ordinary legend recognition)	C	3 (Ordinary orientation)
D	4 (Satisfactory legend recognition)	D	4 (Satisfactory orientation)
E	5 (Excellent legend recognition)	E	5 (Excellent orientation)

2.4. Statistical Methods

2.4.1. Independent Two-Sample *t*-Test

A *t*-test aims to test if the means of two independent samples are equal. To examine gender differences in legend recognition and orientation using questionnaires, a *t*-test was conducted. The assumptions of *t*-test were: the samples are independent, the data's normality, and the variances' homogeneity. The female and male were independent. Additionally, the number of females was 84, and that of males was 94. The sample size was large enough and did not violate the normality assumption. Therefore, we chose *t*-test to investigate gender differences.

(1) Levene's test

For the homogeneity of variances, this study adopted Levene's test. Levene's statistical test is used to assess the equality of variances across multiple groups. If Levene's test indicates this assumption is violated, alternative tests or transformations may be considered. It compares the absolute deviations of individual observations from their group means. The null and alternative hypotheses for Levene's test were as follows:

Null Hypothesis (H0a): The variances of all groups are equal.

Alternative Hypothesis (H1a): At least one group has a variance that is different from the others.

The test statistic W is defined as follows:

$$W = \frac{(N-k)}{(k-1)} \times \frac{\sum_{i=1}^{k} N_i (Z_{i\cdot} - Z_{\cdot\cdot})^2}{\sum_{i=1}^{k} \sum_{j=1}^{N_i} N_i (Z_{ij} - Z_{i\cdot})^2} \quad (1)$$

where

k: the number of different groups;

N_i: the number of cases in the ith group;

N: the total number of cases (the sample size);

Y_{ij}: sample value of the jth cases of the ith group;

$Z_{ij} = \left|Y_{ij} - \overline{Y}_{i.}\right|$, $\overline{Y}_{i.}$ is the mean of ith group;

$Z_{i.} = \frac{1}{N_i} \sum\limits_{j=1}^{N_i} Z_{ij}$ is the mean of the Z_{ij} for group i;

$Z_{..} = \frac{1}{N} \sum\limits_{i=1}^{k} \sum\limits_{j=1}^{N_i} Z_{ij}$, is the mean of all Z_{ij}

W is approximate to the F-distribution with $k-1$ and $N-k$ degrees of freedom. For the gender investigation of this study, $k = 2$ (male and female) and $N = 178$.

(2) *F*-test

The *F*-distribution is defined by the numerator's degrees of freedom (df1) and the denominator's degrees of freedom (df2). The shape of the *F*-distribution depends on these two parameters, and as the degrees of freedom increase, the distribution becomes more symmetric and approaches a normal distribution.

F-value can be used to calculate the distribution's corresponding probability value (p-value) with $k - 1$ and $N - k$ degrees of freedom. If the calculated p-value is less than the chosen significance level, such as 0.05, the null hypothesis is rejected, indicating a significant difference between the groups. At least one group has a variance that is different from the others. In this case, the two groups have different variances.

(3) Independent two-sample *t*-test

After the assumption of homogeneity of variances is achieved, the Student's *t*-test can be performed. The two-sample *t*-test is used to compare the means of two independent groups. The goal is to determine if there is a significant difference between the means of the two groups. If homogeneity of variances are not met, Welch's *t*-test can be performed.

The null and alternative hypotheses for independent two sample *t*-test were as follows:

Null Hypothesis (H0b): The means of the two groups are equal.

Alternative Hypothesis (H1b): The two groups' means are unequal.

The test statistic t is defined as follows:

$$t = \frac{\overline{Y}_1 - \overline{Y}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \tag{2}$$

$$v = \frac{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^2}{\frac{\left(\frac{s_1^2}{N_1}\right)^2}{(N_1-1)} + \frac{\left(\frac{s_2^2}{N_2}\right)^2}{(N_2-1)}} \tag{3}$$

If equal variances are achieved,

$$t = \frac{\overline{Y}_1 - \overline{Y}_2}{s_p\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}} \tag{4}$$

$$s_p = \left(\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}\right)^{1/2} \tag{5}$$

$$v = N_1 + N_2 - 2 \tag{6}$$

where

N_1: the sample number of group 1
N_2: the sample number of group 2
s_1: variance of group 1
s_2: variance of group 2
v: degree of freedom

The t value can be used to calculate the corresponding probability value (p-value) in the t-distribution with v degrees of freedom. If the calculated p-value is less than the chosen significance level, such as 0.05, the null hypothesis is rejected, indicating a significant difference between the groups. On the other hand, if the calculated p-value is greater than the chosen significance level, the null hypothesis is accepted.

2.4.2. One-Way ANOVA (Analysis of Variance)

The one-way ANOVA is employed when there are more than two independent groups to be compared, and the dependent variable is measured continuously. The main goal of one-way ANOVA is to investigate if there is a significant difference among the means of the groups under study. The term "one-way" indicates that only one independent variable is involved in the analysis. Before applying the one-way ANOVA, it is essential to verify the following assumptions:

1. Independence: the observations within each group and between the groups are independent;
2. Normality: the data within each group are normally distributed;
3. Homogeneity of variances: the variances within each group are equal.

The experiment used an easy-to-read/hard-to-read plan; farther/closer exits were dependent variables. Therefore, there are two groups needed to compare. The time of the combinations mentioned above for participants to find the way out is measured, and is the only independent variable. Therefore, one-way ANOVA was adopted to investigate if the means of different groups were equal or unequal. Given *k* independent groups, the one-way ANOVA involves the following calculations:

Step 1: Calculate the group means for each group (*M*i) (i = 1~k) and the overall grand mean (*GM*) of all observations.
Step 2: Compute the sum of squares between groups (SSB):

$$SSB = \sum_{i=1}^{k} N_i(M_i - GM) \tag{7}$$

where N_i is the sample size of group *i*.
Step 3: Compute the sum of squares within groups (SSW):

$$SSW = \sum_{i=1}^{k} \sum_{j=1}^{N_i} \left(Y_{ij} - M_i\right)^2 \tag{8}$$

where Y_{ij} is the sample value of the *j*th cases of the *i*th group.
Step 4: Calculate the degrees of freedom between groups (*dfB*):

$$dfB = k - 1 \tag{9}$$

where *k* is the number of groups.
Step 5: Calculate the degrees of freedom within groups (*dfW*):

$$dfW = N - k \tag{10}$$

where *N* is the total number of observations.
Step 6: Compute the mean squares between groups (*MSB*):

$$MSB = SSB/dfB \tag{11}$$

Step 7: Compute the mean squares within groups (*MSW*):

$$MSW = SSW/dfW \tag{12}$$

Step 8: Calculate the *F*-value:

$$F = MSB/MSW \tag{13}$$

The *F*-value follows an *F*-distribution with *dfB* and *dfW* degrees of freedom. The *p*-value can be obtained using *F*-distribution tables or statistical software. If the *p*-value is less than the chosen significance level (e.g., 0.05), the null hypothesis of equal group means is rejected, indicating a significant difference among the group means.

2.4.3. Post Hoc Analysis Using Scheffé's Method

To further investigate which combination of groups have different means, Scheffé's method is adopted for the post hoc analysis. A post hoc analysis using Scheffé's method is performed when there are more than two groups in a study. The overall ANOVA test indicated a significant difference between the groups. Therefore, the post hoc analysis aims to identify which specific groups differ from each other. The steps for performing Scheffé's method are as follows:

Step 1: Compute the overall F-value, dfB, and dfW for the one-way ANOVA.
Step 2: Compute the Scheffé critical value (S):

$$S = dfB \times F(\alpha, dfB,\ dfW) \tag{14}$$

where k is the number of groups, α is the significance level.
Step 3: Calculate the Scheffé test statistic for each pairwise comparison:

$$S_{ij} = \left(M_i - M_j\right)^2 / \left(MSW \times \left(\frac{1}{N_i} + \frac{1}{N_j}\right)\right) \tag{15}$$

M_i and M_j are the means of groups i and j, N_i and N_j are the sample sizes of groups i and j, respectively, and MSW is the mean squares within groups.
Step 4: Compare each test statistic to the critical value: If $S_{ij} > S$, the difference between the means of groups i and j is considered significant.

2.5. Study Limitaitions

The test site was relatively small in floor area. If a larger test site was adopted, the result may be different. The results of this study and a larger-floor area can then be compared. The experiment participants were new to the test site, but there was minimal time for the evacuee to read the floor plan for an emergency. Therefore, the floor plan that adopted FPV may help reduce the user's reading time. The future research topic was how to highlight the evacuation route for the user to grasp the way out information quickly.

Although the gender difference can be seen in Figure 1, only two questionnaire questions limited the result. However, more related questions are recommended if a future experiment is conducted.

There was a 90° turn in the experiment site. Hölscher et al. [41] discovered that individuals tended to employ various cognitive strategies when planning urban routes. These strategies can be influenced by individual factors such as spatial abilities and familiarity with the environment. The study revealed notable differences in the selected routes concerning efficiency, the number of turns and streets involved, and street size. Zhang et al. [42] examined the influence of route turning angle on compliance behaviors and evacuation performance, which could impact wayfinding behavior during emergencies. This study did not account the turning angle effect.

3. Results

3.1. Questionnaire for Gender Difference in Legend Recognition and Orientation

Eighty-four women (47.2%) and nighty-four men (52.8%) participated in this experiment. The overall sample size was 178. This study investigated gender differences in spatial cognition concerning two key items, legend recognition, and orientation. Table 2 present the performance levels of the men and women in legend recognition and orientation, respectively. If we set "Unfamiliar" = 1, "Neither familiar nor unfamiliar" = 2, "Somewhat familiar" = 3, "Familiar" = 4, and "Very familiar" = 5.

In legend recognition, five out of the 94 male participants (5.32%) expressed that they knew the copy room locations, Corner Café, and the information desk after reading the floor plan. By contrast, after reading the floor plan after reading the floor plan, 26 out of the 84 female participants (30.95%) felt they knew the copy room locations, Corner Café, and the information and service counter. Thirty-six men (38.30%) were unfamiliar with the copy room locations, Corner Café, and the information desk after reading the floor plan. In contrast, only 6 women (7.14%) had the same opinions.

Six out of the 84 female participants (7.14%) for orientation knew the distance between Staircase I and Staircase II after reading the floor plan. Twenty-four out of the 94 male participants (25.53%) knew the distance between Staircase I and Staircase II after reading the floor plan. Thirty women (35.71%) were unfamiliar with these targets when described using vocabularies such as east, west, north, and south and men were 6 (6.38%).

The statistical results demonstrated that for legend recognition, women had a mean of 3.76 and a standard deviation (SD) of 1.168, and men obtained a mean of 1.94 and an SD of 1.056 (upper part of Table 3). For orientation, women had a mean of 2.11 and an SD of 1.203, and men obtained a mean of 3.64 and an SD of 1.125 (lower part of Table 3).

Table 3. Gender difference in legend recognition and orientation performance.

Legend Recognition			
Gender		***n***	**Percentage**
Female	Unfamiliar	6	7.1
	Neither familiar nor unfamiliar	5	6.0
	Somewhat familiar	18	21.4
	Familiar	29	34.5
	Very familiar	26	31.0
	Total	84	100.0
Male	Unfamiliar	36	38.3
	Neither familiar nor unfamiliar	42	44.7
	Somewhat familiar	7	7.4
	Familiar	4	4.3
	Very familiar	5	5.3
	Total	94	100.0
Orientation			
Female	Unfamiliar	30	35.7
	Neither familiar nor unfamiliar	35	41.7
	Somewhat familiar	5	6.0
	Familiar	8	9.5
	Very familiar	6	7.1
	Total	84	100.0
Male	Unfamiliar	6	6.4
	Neither familiar nor unfamiliar	6	6.4
	Somewhat familiar	28	29.8
	Familiar	30	31.9
	Very familiar	24	25.5
	Total	94	100.0

From Figures 2 and 3, we can easily see that females performed better than males in legend recognition and males were better than females in orientation.

Based on the above analyses, for legend recognition, on average, the women thought that they were better than the men; and for orientation, the men thought they were better than the women.

To further investigate whether a gender difference exists in legend recognition, a *t*-test was conducted. It aimed to test whether the means of two groups were different. The hypotheses were set as:

Null Hypothesis (H0c): *$\mu 1$ (mean of female) = $\mu 2$ (mean of male), where μ is the mean.*

Alternative Hypothesis (H1c): *$\mu 1$(mean of female) $\neq$ $\mu 2$(mean of male).*

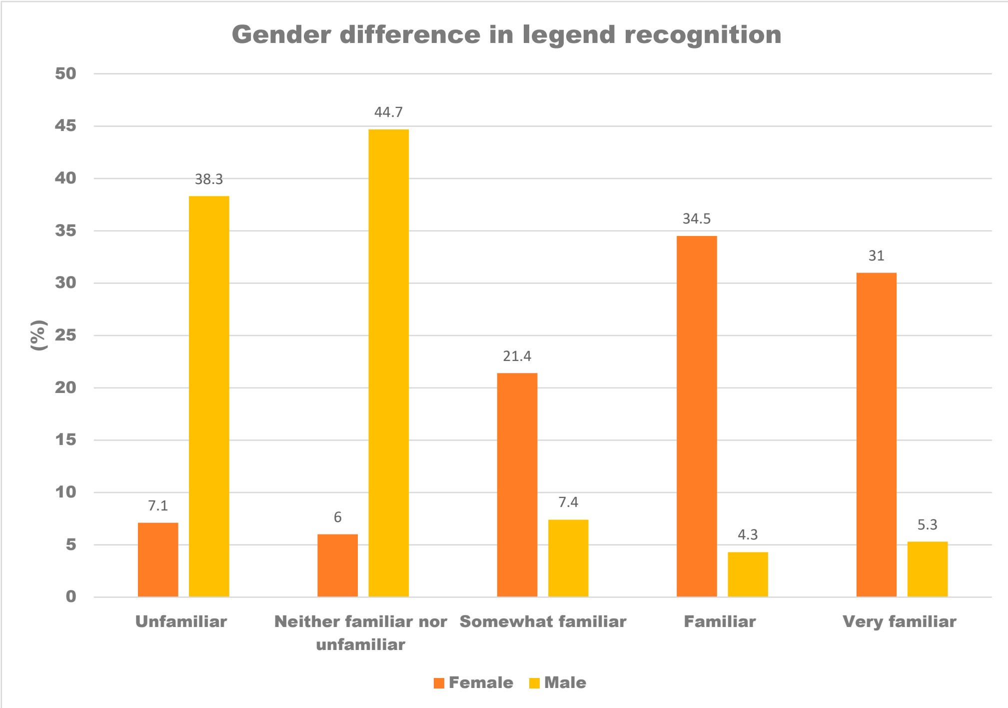

Figure 2. Gender difference in legend recognition.

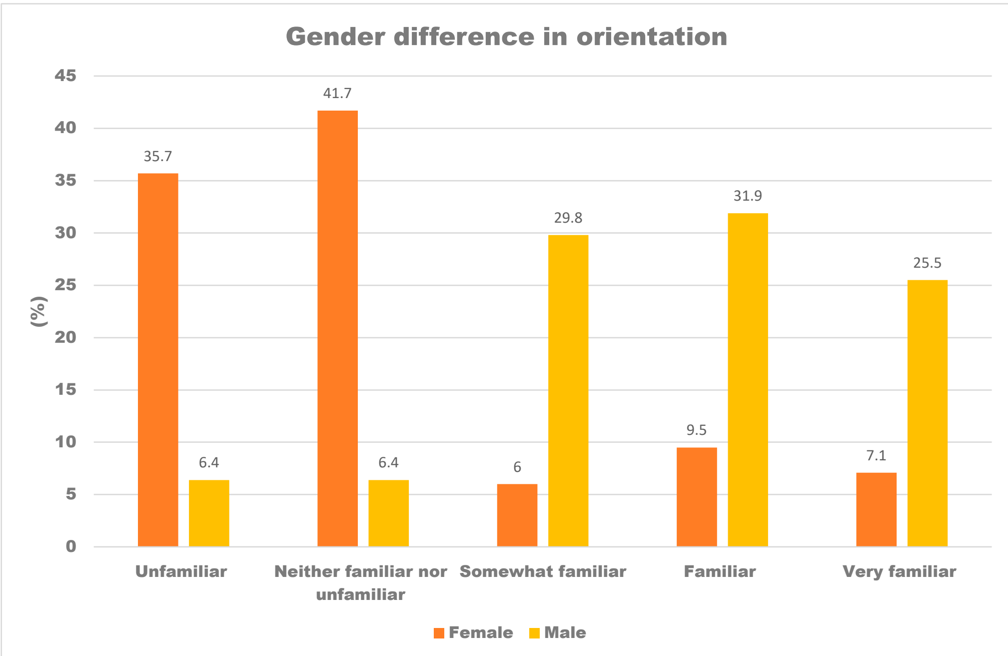

Figure 3. Gender difference in orientation.

This study set 0.05 as the significance level. Levene's test showed $p = 0.055$ (>0.05). The two samples' variances were not significantly different (Table 4). In Table 4, n represents the sample size for each group, SD represents the standard deviation, p represents probability or p-value, F represents F-value, and t represents the t-value.

Table 4. Gender difference in the *t*-test results on legend recognition.

Group Statistics										
		Gender		*n*		Mean		SD	Standard Error of the Mean (SEM)	
Legend recognition		Female Male		84 94		3.76 1.94		1.168 1.056	0.127 0.109	
Independent samples *t*-test										
		Levene's test		*t*-test with an equal mean						
		F	*p* (Significance)	*t*	Degrees of freedom	*p* Significance (two-tailed)	Difference in average	Difference in SD	Confidence interval: 95% Lower bound	Upper bound
Legend recognition	Assuming the variances are equal	3.727	0.055	10.955	176	0.000	1.826	0.167	1.497	2.155

A *t*-test was also conducted to investigate whether a gender difference existed in orientation. The hypotheses were set the same as that of legend recognition. Results of the independent samples *t*-test showed $t = 10.955$ and $p = 0.000$ (<0.05), achieving significance. Therefore, it concluded that the H0 was rejected and H1 was accepted. Furthermore, the result suggests that the means of females and males differed. The mean of females was 3.76, and the mean of males was 1.94. Therefore, the hypothesis that women were superior to men in legend recognition was verified.

This study set 0.05 as the significance level. Levene's test showed $p = 0.672$ (>0.05). The two samples' variances were not significantly different (Table 5). The independent samples *t*-test showed $t = -8.774$ and $p = 0.000$ (< 0.05), achieving significance. It concluded that the H0 was rejected and H1 was accepted. The result suggests that the means of females and males differ. The mean of males was 3.64, and the mean of females was 2.11. Therefore, the hypothesis that men are superior to women in orientation was verified (Table 5).

Table 5. Gender difference in the *t*-test results in orientation.

Group Statistics										
		Gender		*n*		Mean		SD	Standard Error of the Mean (SEM)	
Legend recognition		Female Male		84 94		2.11 3.64		1.203 1.125	0.131 0.116	
Independent samples *t*-test										
		Levene's test		*t*-test with an equal mean						
		F	*p* (Significance)	*t*	Degrees of freedom	*p* Significance (two-tailed)	Difference in average	Difference in SD	Confidence interval: 95% Lower bound	Upper bound
Legend recognition	Assuming the variances are equal	0.180	0.672	−8.774	176	0.000	−1.531	.175	−1.876	−1.187

Based on our results, we can reasonably infer using legends as an aid when showing directions to women and using orientation. Additionally, showing directions to men can generally help the inquirers understand the path and arrive at the destination quickly.

3.2. On-Site Experiment

3.2.1. General Result

Four situation combinations were then generated. Table 6 shows that the average time for reading Floor A takes 17 (s), which is more than that of reading Floor Plan B (28 (s)). In Table 6, *n* is the sample of each group, SD is the standard deviation, and SEM is standard error of the mean. It also shows that Scenario DF took participants the most time in the experiment (169.96 (s)), Scenario DC placed second (153.82 (s)), followed by Scenario EF (113.40 (s)), and Scenario EC consumed the least time (113.40 (s)). The result was reasonable because the plan was easy to read, and the designated staircase was closer to the starting point. EC means the participants read the easier-to-read floor plan and were closer to the starting point to the Staircase II. In this case, it took the participants the least time. On the other hand, the participants read the more challenging floor plan for DF and went to Staircase I, which was farther from the starting point. In this case, it took the participants the most time.

Table 6. Statistics of time spent of the status combinations.

	n	Mean	SD	SEM	Minimum	Maximum
EC	21	98.33	2.921	0.637	95	105
DC	92	153.82	12.432	1.296	135	175
EF	40	113.40	12.027	1.902	92	133
DF	25	169.96	3.182	0.636	165	175
Total	178	-	-	-	92	175

3.2.2. One-Way Analysis of Variance (ANOVA)

An ANOVA was conducted further to investigate the time difference between the four scenarios. The one-way analysis of variance (ANOVA) was used to compare the mean differences between multiple groups. If the group effect was significant, post hoc comparisons were conducted to confirm the differences between the groups. The significance level was also set to $p < 0.05$. The hypotheses were set as:

Null Hypothesis (H0d): The means of all groups are equal.

Alternative Hypothesis (H1d): At least two groups have unequal means.

Table 7 presents the results of the four-factor combinations. In Table 7, *p* represents a probability or *p*-value, and *F* represents an *F*-value on an *F*-distribution. In ANOVA analysis, *F*-value was calculated by dividing two mean squares. The between-group *F*-value was determined to be 301.899, and $p = 0.000 < 0.05$. A larger *F*-value indicates a greater between-group difference (relative to within-group difference). It was concluded that H0 was rejected and H1 was accepted. It means that the means between groups were significantly different.

Table 7. One-way ANOVA.

Time					
	Sum of Squares	Degrees of Freedom	The Average Sum of Squares	*F*	*p* Significance
Between-group	104,723.055	3 (*dfB*)	34,907.685	301.899	0.000
Within-group	20,119.085	174 (*dfW*)	115.627		
Total	124,842.140	177			

To investigate which means were significantly different in groups, a post hoc analysis using Scheffé's method was performed. The significance level was also set to $p < 0.05$. Table 8 shows the result. In it, SD represents standard deviation, *p* represents probability or *p* value.

Table 8. Post hoc test: multiple comparison.

Time (s)						
Factor Combination (A)	Factor Combination (B)	Mean Difference (A − B)	SD	*p* (Significance)	Confidence Interval: 95%	
					Lower Bound	Upper Bound
EC	DC	−55.482 *	2.601	0.000	−62.82	−48.14
	EF	−15.067 *	2.898	0.000	−23.25	−6.89
	DF	−71.627 *	3.183	0.000	−80.61	−62.64
DC	EC	55.482 *	2.601	0.000	48.14	62.82
	EF	40.415 *	2.037	0.000	34.67	46.16
	DF	−16.145 *	2.425	0.000	−22.99	−9.30
EF	EC	15.067 *	2.898	0.000	6.89	23.25
	DC	−40.415 *	2.037	0.000	−46.16	−34.67
	DF	−56.560 *	2.741	0.000	−64.30	−48.82
DF	EC	71.627 *	3.183	0.000	62.64	80.61
	DC	16.145 *	2.425	0.000	9.30	22.99
	EF	56.560 *	2.741	0.000	48.82	64.30

* $p < 0.05$ for mean difference.

DF exhibited significance when compared with EF, DC, and EC. For DF and EC, MDF−MEC = 71.627, SD = 3.183, and p = 0.000 (<0.05), exhibiting significance (Table 8). MDF represents the mean of DF and MEC represents the mean of DF. The difference of the two can be found in the column labeled "Mean difference" in Table 8. For DF and DC, MDF−MDC = 71.627, SD = 3.183, and p = 0.000 (<0.05), exhibiting significance. For DF and EF, MDF−MEF = 56.560, SD = 2.741, and p = 0.000 (<0.05), exhibiting significance. The result showed that the DF and EC had the largest mean time difference (71.627 s). Therefore, the hypothesis that participants would spend more time with DF than with EC was verified.

The results of other factor combinations were similar and are listed in Table 8. In other words, when participants read a floor plan that was difficult to understand, they took considerably more time to reach the closer staircase than those who read a floor plan that was easy to understand and headed to the farther staircase. In short, the viewer may spend more time reading maps than walking to the exit.

4. Discussion

4.1. Gender Difference in Orientation

Concerning whether a gender difference exists in orientation, the independent samples t-test showed $t = -8.774$ and p = 0.000 (<0.05), achieving significance. Therefore, the hypothesis that men are superior to women in orientation was verified in this experiment.

Galea and Kimura [12] showed that females remembered more landmarks than males did and males took fewer trials to reach the endpoint than females did. In the self-report study, females preferred using landmarks for navigating [43]. On the other hand, males preferred using orientation strategy adopting Euclidean representation of space; for example, distance and directions [43,44]. Saykin et al. [45] conducted tests and found that males outperformed females in spatial processing.

However, four visuo-spatial working memory (VSWM) tasks were performed by Bosco et al. [46], who argued that significant differences favor men in VSWM tasks. However, men and women did not significantly differ in orientation task performance. Additionally, they implied that different performance patterns between men and women may minimize the overall cognitive differences. More studies are needed to clarify the factor affecting human wayfinding behavior.

4.2. FPV Plan for Wayfinding

The investigation showed that the participants spent more time completing the experimental task under the status combination DF than under EC. The time difference exhibited significance, which is reasonable and understandable. In other words, when participants read a floor plan that was difficult to understand, they took considerably more time to reach the closer staircase than those who read a floor plan that was easy to understand and headed to the closer staircase.

As the spatial mapping of controls by Norman [47], more alignment of controls to the locations of the actual device makes people more easily connect the controls to the devices. It also implies that Plan A was easier for the participant to read. Huttenlocher and Presson [48] experimented on children and stated that perspective problems were more complicated than that rotation problems. Our experiment setting of the experiment of the map was the combination of rotation and perspective. It implied that Plan B was much harder to read because it was a rotation-and-perspective problem.

Table 7 shows that when participants read a floor plan that was difficult to understand, they took considerably more time to reach the closer staircase than those who read a floor plan that was easy to understand and headed to the farther staircase. This phenomenon was possible because the floor area of the test site was small; hence, the difference between the distances to Staircase I and Staircase II was nonsignificant. Furthermore, when walking at similar paces, the time difference caused by walking distance was also shorter than that caused by the difficulty of floor plan reading. This phenomenon could be explained using experimental statistics. Assuming an extreme situation in which Participant A spent only 4 s reading Floor Plan A and Participant B spent 48 s reading Floor Plan B, the time difference, thus, yielded would be 44 (s) (Table 6). Because the test site was relatively small in the floor area, the distance between the two staircases was short and a time difference of 44 s was not likely to occur at average paces.

However, this phenomenon may not be supported in long-distance wayfinding behavior. For a more extended hallway, the dominant factor affecting the time difference between the two participants is distance instead of the floor plan reading time. This study explores the people's cognitive ability to use evacuation maps. The hypothetical situation is when people encounter an emergency, use the evacuation maps that can guide safe paths in the right direction, and forward to emergency exits locations quickly and safely.

During the research process, the theoretical hypothesis was put forward: by reading the evacuation map, drawn from the first-person view, people can easily understand and effectively remember important information indicated on the evacuation maps, such as the actual scene, escape directions, paths, and emergency exits locations. Furthermore, we investigated the corresponding relationship between the actual scenery and evacuation maps, such as landmarks and orientations. Additionally, we adopted a *t*-test to test the statistical hypothesis of H0 and H1 for the gender difference in legend recognition and orientation. Finally, an ANOVA analysis and accompanying Scheffé's post hoc analysis were performed to find the most significant mean difference between pair-groups.

Based on the above assumptions, this study designed the experiment methods and questionnaire content. In addition, we took the lead in using the first-person and non-first-person views as experimental variables and taking a questionnaire survey during the experiment. Finally, this research obtained clear and valuable research results: by the first-person view, drawing evacuation maps can reduce evacuation time and indirectly improve safety.

This study explored the influence of two different graphics on people's comprehension of evacuation behavior. With the aid of a specific experimental scenario, we successfully accomplished this objective. Our study is distinguished from prior literature by implementing a groundbreaking methodology that assessed people's survival cognition during evacuation using two different graphics. Compared to Carattin et al.'s [49] virtual environment simulation research, our study demonstrated broader applicability and can be effectively applied to the evacuation planning of any building. Additionally, our study surpassed the limitations of Cheng's [50] previous research that exclusively focused on high-rise buildings and provided more generalizable conclusions.

Notably, the external validity of our study's conclusions was relatively high, as each building had its own unique floor plan, allowing our findings to be broadly applied. While we suggested future research that would necessitate more resources and time, we believe our study adequately addressed current research objectives.

4.3. Implications

Standardization of evacuation plans: The onsite experiment and SPSS statistical analysis results revealed that the consistency between floor plan presentation and the physical arrangement of the site in front of the eyes considerably affected the participants' cognitive abilities. The floor plan created from the first-person perspective was the most easily understandable and recognizable. The use of first-person view floor plans could be adopted as a standard practice for designing and displaying evacuation plans in public buildings, as it was found to improve wayfinding behavior and reduce evacuation times. Adoption of first-person view floor plans as a standard practice: public buildings such as hospitals, schools, and airports could use first-person view floor plans to improve the efficiency of evacuations during emergency situations. To provide easily understandable, appropriate, and safe floor plans, plan designers should create them by referencing exit locations and adopting a first-person perspective. In addition, floor plans should be posted on corridor walls to help the public enter the correct evacuation path or arrive at the safety stairs quickly by using their image-centered cognitive ability. The public's evacuation ability can thus be enhanced.

Gender-specific evacuation plans: The study's results on gender differences in wayfinding behavior and cognition could inform the development of gender-specific evacuation plans that cater to the needs of different groups. Gender-specific evacuation plans could be developed for public buildings such as shopping malls, where there are typically more women than men. For example, the plan could include additional signage or clearer directions to help women navigate the building during an emergency.

Public safety: The findings could be used to train emergency responders and educate the public on the importance of clear and understandable evacuation plans. Training of emergency responders and education of the public: Emergency responders could be trained to understand the importance of clear and understandable evacuation plans, and the public could be educated on the importance of following evacuation procedures during emergency situations.

Building design: Architects, designers, and safety professionals could use the study's results to design buildings that are easier to navigate during emergencies, reducing the risk of casualties and injuries. Design of buildings that are easier to navigate during emergencies: Architects and designers could use the study's results to design buildings that are easier to navigate during emergencies. For example, they could design buildings with clearly marked emergency exits or use color-coded signage to help occupants navigate the building during an evacuation.

Compliance with regulations: Our results showed that when walking distance and evacuation direction are both considered, the public's cognitive ability to understand the floor plan becomes crucial. Therefore, the understandability of floor plans is key to affecting the public's evacuation time. To ensure adherence to two principles mandated in the Regulations Regarding Construction Techniques, the shortest walking distance and two-way evacuation, can be implemented, competent authorities should provide a comprehensive program and strategies regarding floor plan creation and installation, thereby elevating the success rate of evacuations and reduce life and property losses. These restrictions are in place to ensure safe evacuation, as longer walking distances can negatively affect evacuation efficiency. In addition, the evacuation map had better take an FPV view for easy reading, saving some time for evacuation.

4.4. Future Study

FPV studies aimed at evacuations are rare, but a few focused on the FPV-related virtual reality technique [51] and augmented reality [52]. Instead of the think-aloud method for studying wayfinding behavior, Viaene et al. [53] adopted the eye-tracking technique in search of indoor landmarks to provide qualitative data for analysis. Unfortunately, we did not record participants' eye movements with this information, so we cannot tell which part of the floor plan the participants stared at most nor their eye-motion paths. For future studies, it is recommended to adopt this technique.

Tong and Bode [54] suggested that pedestrians naturally tend to avoid exits chosen by most people while favoring exits associated with shorter escape routes, even if they are more heavily used. However, when an exit is completely unused, these preferences shift, and pedestrians choose to follow others irrespective of the exit's features. This implies that in some instances, the shortest routes may be preferable, while in others, they may not be. Gao et al. [55] observed that herding behavior, pedestrians' response time, living habits, and two abnormal behaviors—backtracking and choosing a more distant exit—were evident from the experimental video. The rationale behind selecting a farther exit was that evacuees believed it was closer to the main stairwell. In the present study, the influence of crowds was not considered, and further research focusing on this aspect is recommended.

In contrast, Burigat et al. [56] revealed that the mobile 3-D map with a third-person perspective leads to a shorter orientation time before walking than that of FPV. Additionally, they also argued that a mobile 3D map is easier to read than a mobile 2D map. Therefore, further investigations are needed for FPV of 2D and 3D maps.

As the participants of this study were ordinary persons, the future study can focus on evacuating vulnerable people (e.g., the elderly, pregnant women, people with disabilities). However, they take more time to evacuate. Therefore, how to obtain more time for them to evacuate is crucial. Walking speed, eye level, visual acuity, and education level of the experiment participants are suggested for future studies.

5. Conclusions

An on-site experiment was conducted to assess legend recognition and orientation abilities of men and women during an evacuation scenario. The study found that the consistency between the floor plan presentation and the actual site's physical layout significantly impacted participants' cognitive abilities. Floor plans created from a first-person perspective proved to be the most easily understandable and recognizable.

Statistical analysis using *t*-tests revealed that women (31%) outperformed men (5.3%) in legend recognition, while men (25.5%) surpassed women (7.1%) in orientation tasks. These findings are significant and align with prior research in neuroscience.

Furthermore, a one-way ANOVA analysis highlighted differences in the average time taken by participants when faced with varying combinations of easy/hard-to-read floor plans and closer/farther designated staircases. As expected, the hard-to-read floor plan and farther designated staircase resulted in the longest time taken by participants to complete the test. Conversely, the easy-to-read floor plan and closer designated staircase led to the shortest time.

The study also found that when participants encountered a difficult-to-understand floor plan (not FPV), they took considerably more time (153.82 s) to reach the closer staircase than those who had an easy-to-understand floor plan (FPV) and were heading to the farther staircase (113.40 s). This result suggests that the map's readability plays a more critical role when the distance between staircases is shorter, as the time difference between harder-to-read and easy-to-read floor plans is more significant than that between closer and farther staircases.

In conclusion, this study emphasized the importance of easily understandable and recognizable floor plans in emergency evacuation scenarios. The experiment demonstrated that first-person view floor plans significantly impact participants' cognitive abilities, leading to improved evacuation efficiency. Additionally, the study revealed gender differences in legend recognition and orientation skills, with women excelling in legend recognition and men outperforming in orientation tasks. This aligns with previous neuroscience research findings.

The time taken for evacuation was heavily influenced by the readability of the floor plans, especially when the distance between staircases was shorter. Participants with difficult-to-understand floor plans took much longer to reach the closer staircase compared to those with easy-to-understand floor plans, even when heading to a farther staircase. This highlights the critical role of floor plan readability in affecting evacuation time and emphasizes the need for clear, comprehensible maps during emergency situations.

One of the essential purposes of this study was to explain that during the evacuation process, the evacuation map is an important facility that greatly benefits evacuation safety. Evacuation maps should be used to their full potential. According to the research results, it can be known that it is essential to draw evacuation maps from the first-person view. Each floor cannot use only one evacuation map to represent the evacuation route map of all rooms on the floor. Each room should have its evacuation map. The evacuation map cannot be posted in the room or the stairwell. It should be posted outside the room and in the corridor leading to the emergency exit.

This study researched and analyzed the two axes of the people's cognitive ability to the evacuation map and the distance to the emergency exit. For various types of buildings in Taiwan, the distance from the living room to the emergency exit and the repeated walking distance were stipulated and restricted (Article 95 and Article 93 of the Architectural Technical Rules for Architectural Design and Construction). Based on evacuation safety, the walking distance should not be too long. Therefore, based on the previous experimental results of this study, it is known that the people's cognitive ability to the evacuation map is a crucial factor affecting the evacuation time. It can be seen from this that the evacuation map drawn from the first-person view makes it easy for people to read, which can shorten the escape time and significantly increase the probability of a successful escape.

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