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Article

Evaluating Impacts of Bus Route Map Design and Dynamic Real-Time Information Presentation on Bus Route Map Search Efficiency and Cognitive Load

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Abstract: The purpose of this study was to explore the impact of different design methods of bus route maps and dynamic real-time information on the bus route map search efficiency and cognitive load. A total of 32 participants were tested through an experiment of destination bus route searching, and the NASA-TLX scale was used to measure their cognitive load. Two route map schemes were designed according to the research purposes and application status. One was a collinear bus route map with geographic location information based on a realistic map, the other was a highly symmetric straight-line collinear bus route map without map information, and two different types of dynamic real-time information reminder methods were designed (the dynamic flashing of the number of the bus entering the stop, and the dynamic animated flash of the route of the bus entering the stop). Then, four different combinations of the bus route maps were used for testing through the search task of bus routes available for bus destinations. The results indicated no significant difference in the search efficiency between the map-based bus route map and the linear bus route map, but the cognitive load of the map-based bus route map was higher than that of the linear route map. In the presentation of dynamic real-time information, neither the search performance nor the cognitive load of the dynamic flashing of the route of the bus entering the stop was as good as those of the flashing of the number only of the bus entering the stop. In addition, it was found that, compared with men, the cognitive load for women was more affected by geographic information. The optimization strategies of the bus route map information design were proposed by the comprehensive consideration of the feedback of route maps and real-time information.

Keywords: bus route map; visual search; cognitive load

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1. Introduction

In urban life, the bus stop board is an important tool that people often use when taking public transportation, and its ease of use directly affects people's commuting efficiency and satisfaction [1]. The information displayed on bus stop boards is mainly based on bus routes, and it also contains bus route numbers, dynamic real-time information, and other traffic information, which need to have strong timeliness and accuracy to enable users to find the destination quickly and accurately [2]. The lack of user experience and cognitive load in bus route maps and dynamic real-time information cannot give full play to the advantages of intelligent bus systems. As urban traffic networks are becoming more complex, the increasing amount of traffic information can easily cause difficulties for users to understand and recognize, making it impossible for them to find the available bus in a short time, leading to their frustration [3–7]. It is even more stressful during nighttime rides [8]. With the prevalence of intelligent bus systems, bus stop boards with poor user experience can no longer meet the current transportation needs of the public. It has therefore become an important task to improve the urban commuting efficiency and travel quality by establishing a suitable information design model for intelligent bus services [9,10]. Bus route map design and dynamic real-time information are the main components of bus stop boards, and they both have an important impact on improving search performance and reducing user pressure. The design of the route map and the presentation of real-time information should not only be based on the completeness and accuracy of the information, but should also pay attention to optimizing search performance and user satisfaction, taking care of user experience and preferences, reducing the passengers' load of learning and understanding, and helping them overcome travel barriers [11,12].

Some of the bus route map design patterns in the existing research results have attracted great attention. Ovenden once proposed that the bus route map can be designed with reference to the London Underground route map, by integrating the bus routes passing through this stop into a network layout and design [13], and minimizing visual distractions in the design of a route map [14]. At the same time, there are also related studies suggesting the combination of route maps with actual map locations on the stop board in the specific design of route map [15]. The presentation of the route map can affect the user's destination search efficiency. How to highlight the dynamic real-time information for the intelligent bus system is closely related to the search mode. Only selecting the presentation method to express important information in the design of the bus route map can improve the search performance of the public route map, reducing users' cognitive load. Useful traffic maps help travelers find their way in a strange environment, and the type of travel information service helps attract potential users to transit [16,17]. However, some related research has focused on the macro level but has not yet been tested and evaluated. From the related research, it can be seen that high cognitive load and low search efficiency are two serious problems that need to be solved in bus route map design.

In this study, the bus route map interface was taken as the research object, and the impact of route map design and dynamic real-time information design on user search efficiency and cognitive load were explored based on the visual search theory. A bus stop destination search test was conducted on 32 participants (16 males and 16 females) in the study. The experimental samples were designed for different presentation methods of bus stop board information with unified fonts, colors, and other content of different experimental samples to ensure that the search response time and the cognitive load of the participants were recorded under the controlled conditions in the experiment. It was explored whether the design style of the route map (map-based collinearity with geographic location information, highly symmetrical straight-line collinearity) and dynamic real-time information (the dynamic flashing of the number of the bus entering the stop, the dynamic flashing of the route of the bus entering the stop) affect the search efficiency and cognitive load of the bus route map. The principles of the bus route-finding behavior were further analyzed, the method of presentation in the design of the bus route map and the cognitive mechanism of dynamic real-time information expression were revealed, and the strategies for optimizing the design of the bus route map were provided.

2. Related Works

2.1. Visual Search

Visual search is a perceptual task that requires attention and usually involves a dynamic scan between a specific target object and a variable number of nontarget objects (distractors) in the visual environment [18]. According to passengers' mode of bus searching, they usually want to find the destination and available buses in the shortest time, and most passengers use a random search strategy combining Serial Search and Conjunction Search, as the search area for bus stop boards is relatively limited [19]. Therefore, the calculated reaction time of the participants to complete the search task was taken as the performance evaluation of a stop board in this study; it is also one of the main perception evaluation methods for information design [20]. The different line numbers, stop names, operating hours, and other information presented on the bus route map have certain similarities, so the search time is disturbed by similar information when passengers search for information [21]. Moreover, the design also involves the characteristics and the thickness of the strokes, the height and the aspect ratio of the characters, and the contrast between the numbers and the different lighting levels, which all affect passengers' recognition efficiency [22–24]. At the same time, the limitations of the user's memory, attention, learning ability, decision-making ability, and perception ability must be taken into account when the route map is designed [25]. Therefore, in order to evaluate the rationality of the bus route map and the dynamic presentation of real-time information, in the study, we controlled the font style, font size, lighting brightness, and other interference factors on each bus stop board sample to further identify the impact of the route map design and dynamic real-time information on the visual search performance.

2.2. Bus Stop Route Map Design

Roberts organized the design of traffic route map information into five basic principles: simplicity, coherence, balance, harmony, and topography [26,27]. The purpose of the bus stop route map is to convey the necessary information on buses and to facilitate people's choice of the appropriate buses for reaching the destination [28]. A bus route map that lacks an effective design makes it difficult for passengers to understand the information, which in turn makes it impossible for them to quickly find the information they need on the bus route map [6]. At present, the more commonly used bus route maps for intelligent bus stop boards are straight-line collinear road network maps, in which all routes are designed to be straight lines in order to minimize the visual interference elements [14]. The straight-line maps have strong symmetry and help to improve search performance [29]. At the same time, there are also related studies that suggest that bus route map design can be appropriately combined with geographic location [15], by integrating the bus routes passing through this stop into a network layout and design in reference to the design of the London Underground route maps [13]. The use of horizontal, vertical, and 45-degree angles to present the route, the distance between the stops on the map not being proportional to the actual distance, and other ways are used to optimize the presentation of route information in order to provide effective navigation lines [13,26]. Although the aesthetics of the design are unlikely to have an impact on usability, good shapes and patterns do make people feel pleased [30,31]. Some research evaluated the performance of participants for traffic maps by eye tracking, and proposed that color and legends had a positive impact on road map design [28,32]. A combination of aesthetics, understandability, intuitiveness, and readability can result in advanced traffic maps serving as a good means to convey data but also to make traffic maps attractive to the eye and aesthetically appealing [33]. However, there are no studies that have explored the impact of different layout styles of bus stop route maps on search performance and user cognitive load. A highly symmetrical linear route map and a low-symmetry map-type route map integrating map-related information were designed for this study to test the impact of its combination with dynamic real-time information on user performance and cognitive load. The experimental sample was designed based on the bus route of Taipei City, that considering the relevant factors could affect the information search, typesetting, symmetry, and geographic in-formation.

2.3. Dynamic Real-Time Information Design

At present, passengers' demand for real-time information visualization is also increasing [34,35]. With the popularization of intelligent bus stop boards at this stage, high-resolution interactive screens are widely used in many travel scenarios. However, the traditional paper-based information presentation method is still used for many bus stop boards, which therefore lack an effective design for real-time bus information. The dynamic real-time bus information can effectively present the bus status and relieve user anxiety by providing the estimated arrival time [36,37], and help passengers make corresponding travel decisions [38]. Effective design could reduce the waiting time and the overall travel time, while assisting the transport operators in having a clearer understanding of the current conditions, improving the service quality strategies [39]. Passengers need to make quick judgments due to time pressure, environmental pressure, and other factors. With the addition of dynamic real-time information of buses, passengers often make targeted adjustments and use sequence searching to prioritize the number of buses to enter the stop [40]. Obviously, on the one hand, the dynamic presentation of real-time information makes information prompts and information comprehension more intuitive, and makes it easier to attract the attention of passengers so that they can understand the current state of the bus [34,41–43]. On the other hand, it increases the visual complexity of the information interface, which in turn leads to an increase in task completion time, and results in some negative emotional evaluations [44].

Dynamic real-time information also needs to be discussed in depth in combination with passengers' search habits to understand its impact on search performance and user cognitive load. Two kinds of dynamic effects of buses about to enter the stop were designed by integrating the existing dynamic real-time information styles. One was the flashing of the bus number, and the other was the flashing of the bus route. The impacts of the two methods on search performance and cognitive load need to be studied. The highlight flashing method was used for reminding, and the parameters such as the flashing frequency were reasonably optimized according to the large-screen animation design [34,43].

2.4. Cognitive Load

The NASA-TLX (NASA-Task Load Index) was used to evaluate the users' cognitive load. The subjective evaluation method of cognitive load was to evaluate the workload according to the subjective feelings of work difficulty, time pressure, and nervousness of the participants in operating tasks [45,46]. The most common subjective measure was the Task Load Index (NASA-TLX) of National Aeronautics and Space Administration (NASA), a widely used, subjective, and multidimensional assessment tool that uses perceived workload to assess the effectiveness or other aspects of the performance of a task, systems, or team [47]. NASA-TLX essentially asks participants to answer six scale-rating questions after the completion of one task: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. Because the tool includes measurement of the dimensions of mental and physical demands that are so relevant to today's physical and mobile interfaces, many researchers have been using NASA-TLX as a tool to improve user experience [48].

Therefore, the following research hypotheses were proposed:

Hypothesis 1 (H1). *The search efficiency of the linear route map is significantly higher than that of the map-based route map.*

Hypothesis 2 (H2). *The cognitive load of the linear route map is significantly lower than that of the map-based route map.*

Hypothesis 3 (H3). *The search efficiency of bus route flashing in dynamic real-time information is significantly lower than that of bus number flashing.*

Hypothesis 4 (H4). *The cognitive load of bus route flashing in dynamic real-time information is significantly higher than that of bus number flashing.*

Hypothesis 5 (H5). *Route map and dynamic real-time information visual design have interactive effects on search efficiency and user cognitive load.*

3. Methods

This study tested the search performance of different types of route maps and dynamic real-time information designs in intelligent bus stop boards, and measured the cognitive load of the participants through the NASA- TLX questionnaire to obtain the optimal combination (as shown in Figure 1).

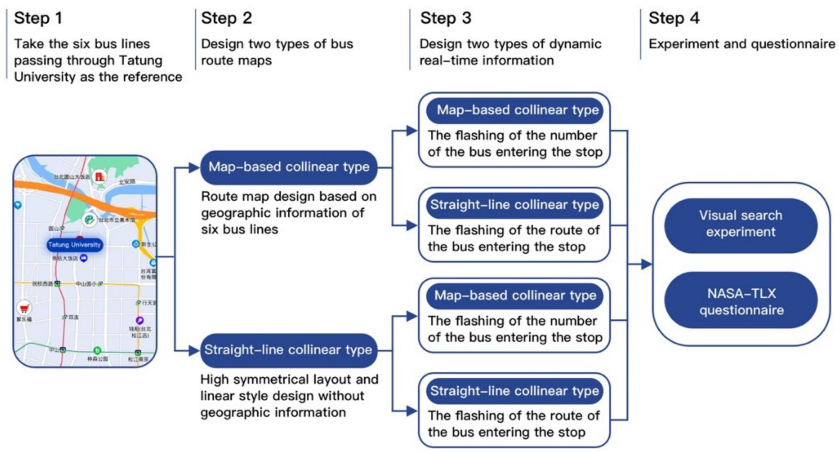

Figure 1. Research flow.

3.1. Participants

A total of 32 participants (18 to 33 years old, M = 23.56, SD = 4.04) were selected for this study, including 16 males, M = 22.6, SD = 3.72, and 16 females, M = 24.4, SD = 4.42. This study adopted the between-group design of 2 (Bus route map design: map-based and linear type) × 2 (Real-time information: number flashing and route flashing). A total of 32 participants were divided into two groups on average. Each group had 8 males and 8 females. All participants were volunteers with normal eyesight or normal eyesight after correction. All participants passed the color blindness examination. Each participant was completely unfamiliar with the lines and stops in the experimental sample.

3.2. Experimental Variables

In this study, different visual designs of bus route maps and dynamic real-time information were treated as independent variables, while search efficiency and cognitive load were regarded as dependent variables. Two designs of the bus route maps were adopted, the straight-line collinear road network map with high symmetry, and the route map with low symmetry reflecting the geographical locations (as shown in Figure 2). One of the dynamic real-time information designs was only the highlighting of the bus number in the approaching bus animation, and the other was the highlighting of the approaching bus route (as shown in Figure 3). In the experimental sample map, the bus stops near Tatung University, Taipei City were taken as the current location, the routes of the six bus lines (218, 310, 612, 42, 247, Zhongshan Line) passing through the stops were selected as the reference, and such software as Sketch (a software used for user interface design) was adopted to draw the map-based bus route maps [49]. At the same time, in order to avoid factors such as the existing place names and the different residences of the participants affecting the accuracy of the experiment, all the sample stop names were based on the 24 solar terms and the titles of 300 Tang poems. At the same time, for comparison of the differences in the bus stop information design, the four stop board samples were consistent in terms of text, color, icon, and other content to ensure that the experimental results were not affected by other factors.

This study adopted the between-group design of 2 (bus route map design: map-based and linear type) × 2 (real-time information: number flashing and route flashing). The experimental samples used in one group was the flashing of the number of the bus entering the stop (the straight-line collinear route map and the map-based collinear route map), while the experimental samples used in another group was the flashing of the route of the bus entering the stop (the straight-line collinear route map and the map-based collinear route map). Participants belonging to each group only completed the samples of its group. In all tests, bus route map design and real-time information were regarded as independent variables, while the search time and the cognitive load were regarded as dependent variables. The experiment was in a complete Latin Square design to eliminate the possible sequential effect [50]. The factors of information combination and the selection of their levels are explained in Table 1.

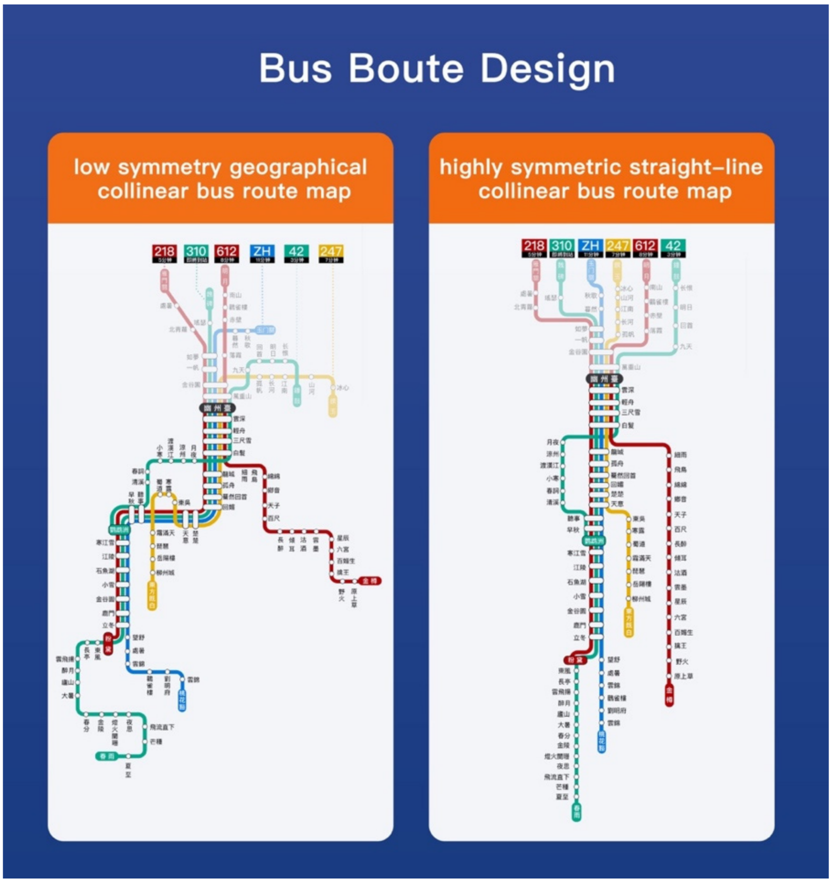

Figure 2. Presentation methods of the bus route map.

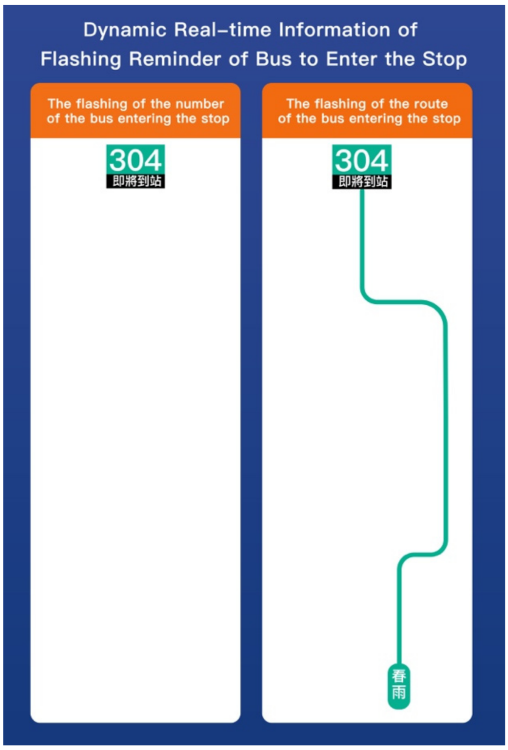

Figure 3. Dynamic real-time information of flashing reminder of a bus entering the stop.

Table 1. Experimental Sample Variables.

Experiment	Independent Variable	Hierarchy
Search of buses available	Bus route map design	Straight-line collinear type Map-based collinear type
	Dynamic real-time information design	The flashing of the number of the bus entering the stop The flashing of the route of the bus entering the stop

3.3. Experimental Design

The experiment was carried out in two stages. Before the experiment, the experiment content was explained with simplified graphics to help the participants understand the experiment content as well as the route map design and the definition of the dynamic reminder of the bus entering the stop. During the formal experiment, no explanation of the content was provided, and the participants were not allowed to ask questions either. Thus, the extent of the participants' understanding of the graphic presentation for the first time could be studied.

In the first stage, this experiment explored the impact of different ways of presenting bus stop board information on search performance (as shown in Figure 4). Participants were asked to complete relevant search tasks on intelligent bus information boards. First, the participants were informed of the destination that needed to be queried, then looked at the screen and searched for the bus that could be taken to reach the destination on the bus stop board that appeared next when the timing started. When the participants figured out the available bus schedule, the task was considered completed and the timing ended. To balance the experimental error, the participants had to query four different destination stops on each sample, which were located at different locations on the bus route map.

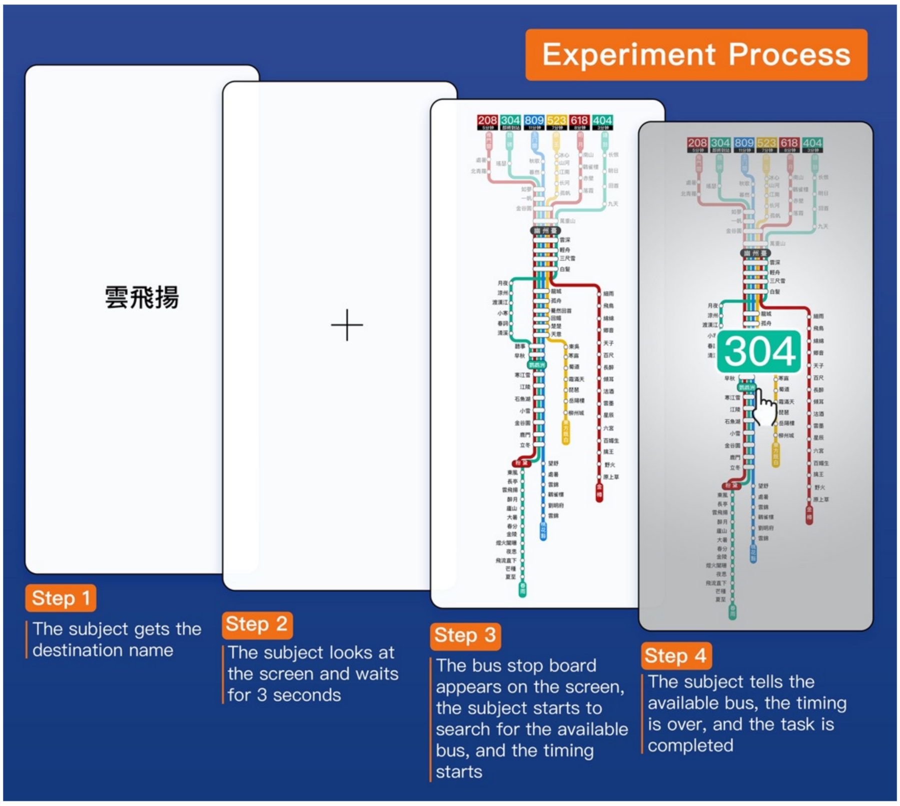

Figure 4. Experiment process flow.

The second stage of the experiment was mainly to understand the difference in the cognitive load of the participants facing different experimental samples. Therefore, after the end of the previous stage of the experiment, the NASA-TLX questionnaire was distributed to investigate the cognitive load of each sample through a 7-point Likert scale.

3.4. Experimental Equipment

The 55-inch LCD display (Figure 5) specially used in public places, provided by Taiwan Design Integration Enterprise in the 1970s, was adopted as the experimental stop board display. The LCD display has a 17:10 aspect ratio, brightness of 550 cd/m^2, screen resolution of 1920 × 1080, and an actual display range size of 1300 mm (W) × 760 mm (H). Both the text and images on the stop board were clearly displayed after the prepared intelligent stop board sample was imported into the interactive large screen. In order to meet the needs of each user's visual conditions and to observe the interaction between the participants and the stop board at the same time, the distance between the participants and the screen was not limited in this experiment (the visual distance of text for those with normal vision was about 2 m). The participants could stand at a distance or close to the screen and even point with a finger to help them in their search [51], and a camera was set on the left to record the reaction time of the participants facing different samples to complete the task.

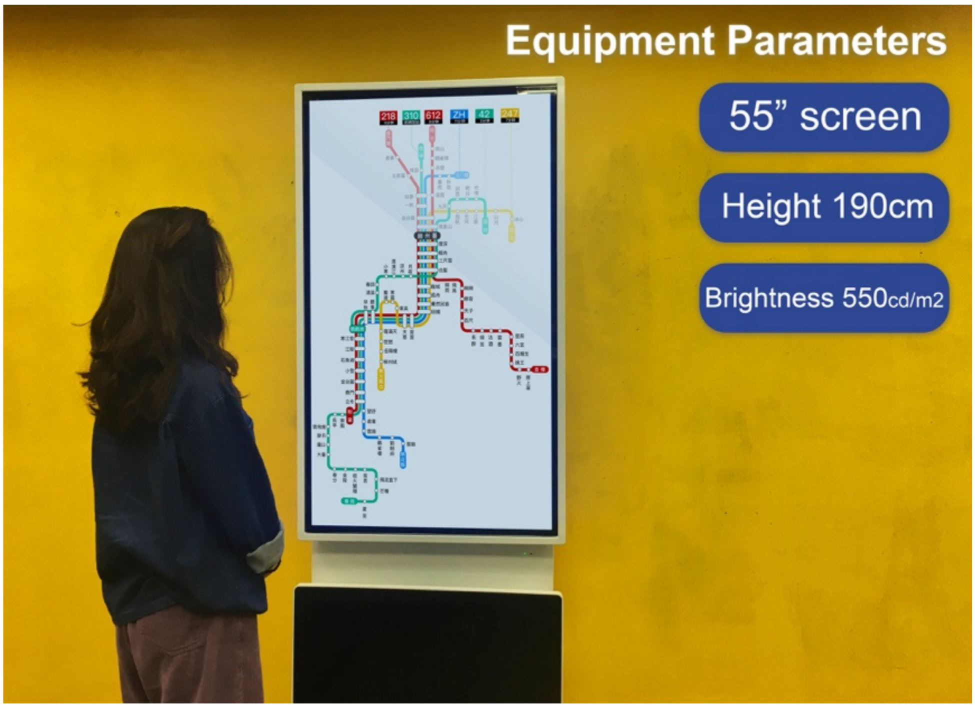

Figure 5. Experimental equipment and scenario.

4. Result

In this study, the intelligent bus stop board information was taken as the research object to investigate the impact of bus route map design and real-time information dynamics on user performance and satisfaction, to analyze the reasons, and then to obtain information design principles suitable for application in the field of public transportation. All valid data were analyzed with SPSS version 20.0 in this study.

4.1. Search Performance

The evaluation of search performance can analyze and investigate whether there are differences in different bus route map designs and dynamic real-time information through the completion time of the subject's search task of available routes. The method of repeated measures was used for comparison between groups, and the results are as follows (Table 2, Figure 6):

Table 2. Repeated Measures Results of Search Time.

Independent Variable	Level	M	SD	F	*p*
Route map design	Map-based Linear type	12.436 12.147	6.199 6.100	0.074	0.788
Real-time information	Number flashing Route flashing	10.315 14.268	4.391 6.962	19.805	0.000

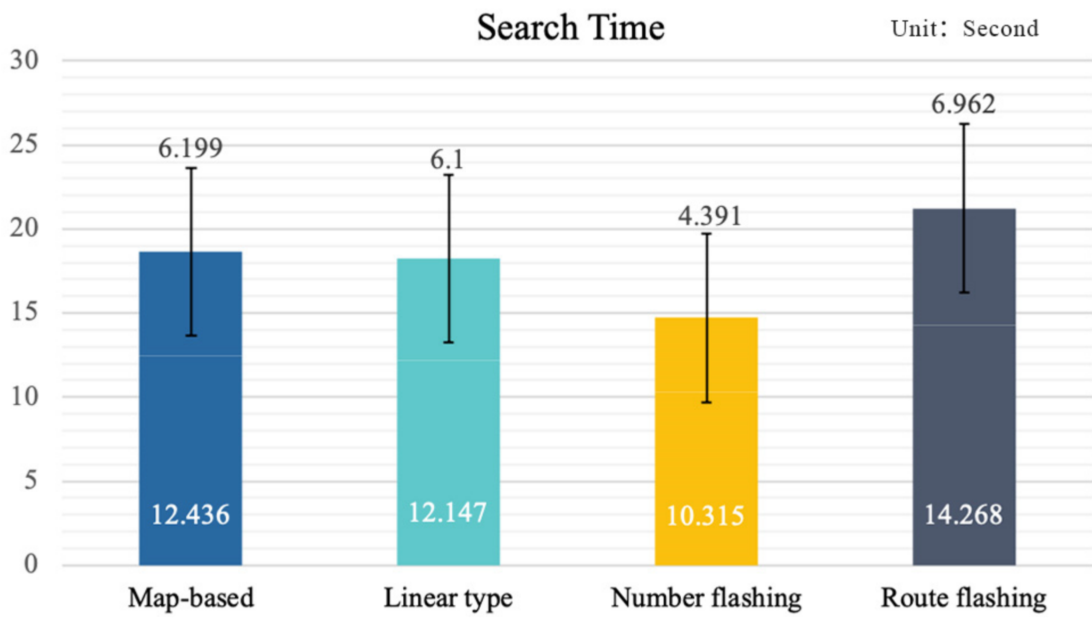

Figure 6. Results of search time.

The task completion time for bus stops using the map-type route map (M = 12.436, SD = 6.199) was higher than that of the linear route map (M = 12.147, SD = 6.100), but there was no significant difference between the two ($p = 0.788 > 0.05$), so H1 was not established.

The task completion time of the group of the stop boards using the flashing of the approaching bus route (M = 14.268, SD = 6.962) was greater than the group of the stop boards using the flashing of the approaching bus number (M = 10.315, SD = 4.391). There was a significant difference ($p = 0.006 < 0.05$) and so H2a was established.

When facing the map-type route map, males (M = 10.663, SD = 4.793) had a better search performance than females (M = 14.210, SD = 6.973), and the difference was significant ($p = 0.008 < 0.05$).

When facing the number flashing route map, males (M = 9.227, SD = 3.709) had a better search performance than females (M = 11.403, SD = 4.795), and the difference was significant ($p = 0.033 < 0.05$).

When men and women were faced with the linear route map and the route map of route flashing, the search performance of men was better than that of women, but there was no significant difference between the two (Tables 3 and 4).

Table 3. Search Time of Different Route Map Designs.

Independent Variable	Gender	Map-Based (M)	*p*	Linear Type (M)	*p*
search time	Male Female	10.663 14.210	0.008	11.378 12.915	0.333

Table 4. Search Time of Different Real-Time Information.

Independent Variable	Gender	Number Flashing (M)	*p*	Route Flashing (M)	*p*
search time	Male Female	9.227 11.403	0.033	12.814 15.721	0.072

The experimental results showed that there was no interaction between route map design and dynamic information.

4.2. Cognitive Load Assessment

The analysis of the bus route map cognitive load was used to analyze the cognitive load scores of all participants collected during the test and to determine whether there were differences due to different presentations of the bus route map design (Table 5, Figure 7). The method of repeated measures was also adopted in this study for comparison of the groups. The results showed that the cognitive load of the map-type design of the bus route map was significantly greater than that of the linear type ($p < 0.050$) in terms of mental demand, physical demand, temporal demand, frustration level, and effort, and the cognitive load of the route map with the flashing of the route of the bus entering the stop was greater than that of the route map with the flashing of the number of the bus entering the stop ($p < 0.050$).

Table 5. Descriptive Statistics of Cognitive Load.

Independent Variable	Level	M	SD	F	*p*
Mental Demand	Map-based Linear type	4.938 3.5	2.1 1.763	20.208	0.000
	Number flashing Route flashing	3.547 4.891	2.282 1.561	30.318	0.000
Physical Demand	Map-based Linear type	2.547 2.078	1.425 0.931	5.947	0.021
	Number flashing Route flashing	2.047 2.578	1.075 1.307	16.452	0.000
Temporal Demand	Map-based Linear type	4.484 3.547	2.023 1.763	14.004	0.001
	Number flashing Route flashing	3.547 4.484	1.975 1.817	23.936	0.000
Performance	Map-based Linear type	3.656 2.969	2.01 1.522	5.578	0.025
	Number flashing Route flashing	3.156 3.469	1.766 1.851	6.424	0.017
Effort	Map-based Linear type	4.359 2.5	1.684 1.234	95.726	0.000
	Number flashing Route flashing	3.281 3.578	1.741 1.744	3.642	0.066
Frustration level	Map-based Linear type	3.563 2.219	2.13 1.119	24.24	0.000
	Number flashing Route flashing	2.484 3.297	1.782 1.788	27.743	0.000

In terms of the degree of frustration, there was no significant difference between the cognitive load of the flashing of the number of the bus entering the stop and the flashing of the route of the bus entering the stop. The cognitive load of the map-based design was greater than that of the linear-type sample ($p < 0.000$); H1b was therefore supported and H2b was not supported.

In terms of cognitive load, men and women performed the same for each item, and there was no significant difference. At the same time, the experimental results showed that there was no interaction between route map design and dynamic information on search performance and cognitive load; thus, H3 was not supported.

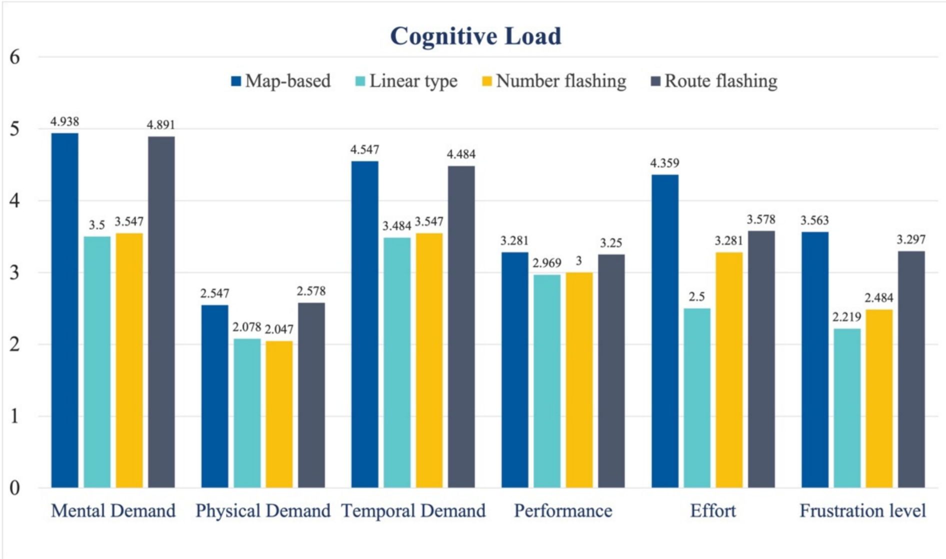

Figure 7. Results of cognitive load.

4.3. Discussion

The experimental results showed that the expression of the two main design elements of bus route map information—route map design (map-based, linear type) and dynamic information (number flashing, route flashing)—had different impacts on the destination search efficiency and user cognitive load.

Under the condition that gender, age, spatial familiarity, spatial cognitive ability, and environment were similar, the cognitive load of the map-based route map was higher than that of the linear-type route map, which is in line with the relevant research proposing that the establishment of a hierarchical visual knowledge representation helps to reduce the visual perception of disorder in the human–machine interface, and can reduce the load input in the cognitive process [52]. A highly symmetric linear route map can more intuitively and clearly reflect the structure of route information, enhance the user's sense of hierarchy, is superior to the map-based route map in terms of order, and reduces cognitive load. In actual situations, if passengers have a certain degree of familiarity and mastery of geographic information for some basic orientation concepts, their pressure on cognitive load would be greatly reduced.

From the perspective of search efficiency, although the map-based route map incorporated geographic location information and increased the visual complexity of the route map, there was no significant difference in search performance between the map-based route map and the linear route map. Although geographic location information was added to the route map, the design principle was optimized by referring to the underground route map [13], so there was no significant difference in the time of searching for the buses for the destination.

The results of this study showed that men and women only showed significant differences in search performance when faced with the map-based route map design. It can be seen that the impact of route map design presentation on the cognitive load and search efficiency of men was greater than that of women, which is the same as the results of Yan et al [53]. In the process of converting route maps to mental maps, men are more sensitive to spatial relationships, while women are more sensitive to symbols and location and other details, so the way the route map is presented has a greater impact on women. Lawton indicated that the degree of anxiety and uncertainty of women in an unfamiliar environment in the process of wayfinding was higher than that of men, and it was pointed out that anxiety reduced their search ability [54], which also proves that the level of anxiety affects women's performance in wayfinding. Bradley suggested that women showed great uncertainty when drawing cognitive maps [55]. This also makes women have a lower search performance than men in the face of some complex maps.

Under the premise that gender, age, spatial familiarity, spatial cognition, and environment remained unchanged, the route map with bus number flashing outperformed the route map with bus route flashing in both search performance and cognitive load. The difference in the design of the method of dynamic display also formed different degrees of visual complexity. As indicated by Tuch [44], the increase in visual complexity leads to the increase in task completion time, and at the same time, it leads to some negative evaluation emotionally and the increase in facial muscle tension physiologically. Therefore, high-complexity visual interfaces bring more negative impressions than low-complexity visual interfaces. According to the theory on visual selective attention, visual information processing is selective; the first is to focus on cued targets, and users generally ignore distracting information that is not relevant to the task [56]. When the destinations are randomly distributed on the route map, the dynamic information of the flashing reminder would distract the participant's attention. Therefore, when the dynamic design is integrated into the entire route map, it would create interference to the passengers in their search and use, which is also in line with the spotlight model that the human brain cannot efficiently process all stimuli in the visual range of attention. The theory treats attention as a spotlight, that is, the only area that can be clearly seen. When stimuli fall outside the spotlight area, the information can be ignored and it is difficult to analyze it, while stimuli within the spotlight area can be effectively processed sensitively and perceptually. The results of the study showed no difference in the impact of the dynamic design on men and women.

The results showed that the effects of route map design and dynamic real-time information on the participants' attention were independent of each other, and there was no significant interaction, which is also consistent with the research results of Wang and Fang on map design and other aspects [57,58].

5. Conclusions

Through the visual search task of destinations on bus stop boards, the impacts of the route map design (map-based, linear type) and dynamic alerts for real-time information (the flashing of the number of the bus entering the stop, the flashing of the route of the bus entering the stop) in information design for bus route maps on user navigation efficiency and cognitive load were investigated in this study, and the potential causes of these effects were explored. The following three conclusions were drawn:

(1) The cognitive load of users who used the map-type bus route map was higher than that of the linear route map, However, the search efficiency of users using the map-type bus route map was not significantly different from that of the linear route map. When designing a route-map, the details of geographic location information could be appropriately increased.
(2) The search efficiency of the bus route map with real-time information of the flashing of the route of the approaching bus was significantly lower than that of the flashing of the number. The cognitive load of the flashing of the bus number was lower than the flashing of the bus route. Route map design and dynamic real-time information did not interact in terms of search efficiency or cognitive load. The design of dynamic real-time information should control the range of highlight reminding to avoid reducing visual search efficiency.
(3) In terms of route map design and dynamic real-time information, there was no significant difference in cognitive load between men and women, but in terms of search performance, when faced with the map-based route map design, men's search efficiency was significantly higher than that of women.

In this study, quantitative methods were used to evaluate the impact of design elements of bus route maps on navigation efficiency and cognitive load. To broaden the research perspective and research methods of public transport information design, new theoretical support for bus information design should be provided, and the presentation of bus route maps should be optimized. The research results have certain significance for improving the search efficiency and design method of bus route maps. These findings have practical significance for people who rely on public transportation, and provide applicable guidance on the design for future public transportation information.

However, this study had some limitations. Subject to project resources and experimental requirements, the participants in this study were between the ages of 18 and 33. To account for the needs of an aging population, future studies could recruit middle-aged and older adults as participants to evaluate the search efficiency and cognitive load of bus stop board information. In addition, users may have different cognitive patterns and different psychological pressures in different types of bus waiting places and in different travel situations. Our future study will investigate and verify whether the conclusions of this study are applicable to other ages, identities, and public transport scenarios.

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