受付番号:	JSSDJ-D-13-00053R1
論文種別:	論文 / Original Articles
標題:	Investigation on design and usage of P-type bus stops toward elders
標題（英語）:	Investigation on design and usage of P-type bus stops toward elders
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抄録:	The aim of investigation was mostly focused on using P-type bus stops of elderly in Taiwan. By conducting participant observation and interview survey, we obtained the ability of identify, legibility, image recognition, observation distance, and visual search capabilities of elderly. The verbal protocol analysis was used to analyze the effectiveness and requirement of bus stop sign then redesign and usability evaluation. Research results showed that the upright bus stop sign with separate bus stops and routes information typesetting was the most reputable design for providing a better humanized, safe, and comfortable transportation environment.
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分野:	Design Case Studies; Human Factors; Universal Design; Graphics; Information Design
キーワード:	elderly people, the P-type bus stop, Verbal protocol, information design, information communication
査読者への回答:	Dear Sirs, 1.We would like to thank the reviewers for their insightful and valuable comments. 2.Revision has been made according to the suggestions of the reviewer. (Revised manuscript is in red). Kindly help me and let me know if I am wrong or misleading in the revised manuscript. Please correct any errors that you find. --- 査読者 #1 : This study redesigned bus stops after conducting investigations. It's a really practical study which evaluates the proposed design plan and contributed greatly to public design. Some details of the research progress should be added to make the study easier to understand. After observing the bus stops, how to differentiate information conveyance and human factors should be explained. In the ten participants' interview analysis, more explanation should be made on how to define the ability of identify, legibility, image recognition, observation distance, and visual search capabilities. Besides, in the post-investigation after redesigning the bus stops, the number of senior participants and more details of the investigation should be clearly stated. In the conclusion part, the following issues should be elaborated more: the difference between words printed in a horizontal or a vertical way, and its influence to the design

of bus stops.

Author's response：
The definition of the scopes of information communication and human factors, and five categories of bus stop information design factors were based on the participant observation and oral information of 10 elderlies from the first stage investigation. The results were analyzed and summarized into two major scopes: information communicated and human factors and then coding according to five categories.Please refer to page3 in revised manuscript for the changes.

Original manuscript-P.3:
The factors affecting the information design of bus stop signs include the following five categories:

Revised manuscript-P.3:
This research was conducted to employ the coding for the bus stop information communication investigation based on the results of participant observation from the first stage. Factors that affect the information design of bus stop signs are classified into following five categories: For the investigation content, please refer to the details of "3. Investigation Results and Analyses".

Original manuscript-P.3:
This study divided the factors affecting the information design of bus stop signs into two categories, information conveyance (C1) and human factors (C2). The categories and coding framework are summarized, as shown in Table 2, and used as the coding system.

Revised manuscript-P.3:
This study through the results of participant observation and interview of first stage is divided the factors affecting the information design of bus stop signs into two categories, information conveyance (C1) and human factors (C2) （About the analysis content, please consult the some explanation of " 3. Investigation Results and Analyses"）. The categories and coding framework are summarized, as shown in Table 2, and used as the coding system.

査読者 #2：This paper should be made more concise and contributed to Annual Design Review of JSSD. In order to accept this paper as an original article, the conclusion must be generalize.

Author's response：
The revision of conclusion section has made according to the suggestions of two reviewers. Please refer to page10 in revised manuscript for the changes.

Original paper

INVESTIGATION ON DESIGN AND USAGE OF P-TYPE BUS STOPS TOWARD EDLDERS

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Abstract: The aim of investigation was mostly focused on using P-type bus stops of elderly in Taiwan. By conducting participant observation and interview survey, we obtained the ability of identify, legibility, image recognition, observation distance, and visual search capabilities of elderly. The verbal protocol analysis was used to analyze the effectiveness and requirement of bus stop sign then redesign and usability evaluation. Research results showed that the upright bus stop sign with separate bus stops and routes information typesetting was the most reputable design for providing a better humanized, safe, and comfortable transportation environment.

Keywords: *Elderly people, The P-type bus stop, Verbal protocol, Information design ,Information communication*

1. Introduction

In 1996, 7.0% of the population were the elderly aged 65 and above, and Taiwan formally became an aging society. At present, the elderly population has increased by 10.6% [1]. The elderly population will account for 29.2% of the total population by 2036, and Taiwan will become a "super-aging society" [2, 3]. With the increase in age, their lifestyle and needs for transportation differ from those of other age groups. They usually take a bus, the MRT (metro rapid transit), or walk, as their main modes of transportation.

Visual degradation is the leading cause affecting the reading of bus stop signs by the elderly. The elderly's color differentiation significantly decreases with an increased age. Therefore, text tends to become blurred and they experience eyestrain [4,5]. In terms of psychological functions, decreased cognitive abilities, such as decreased memory performance , affect their abilities in information retrieval. To prevent the elderly from encountering the distress caused by taking buses [6], bus stop designs should provide the elderly with sufficient bus information, and particular design methods, such as symbols and systemic approaches, should be used to reduce obstacles, as well as the senses of insecurity and distrust when taking buses [7-9]. This study intends to use Kansei engineering (affective engineering) to transform the cognitive and imagery expectations of the elderly into physical design elements [10-12] by further designing two types of bus stop signs, and then enroll the elderly as the subjects for interviews in order to test the practical effectiveness of the newly designed bus stop signs.

This study investigated the information conveyed by "P-shaped bus stop signs", from the perspective of the elderly, in order to develop a public-oriented urban transportation system through both the software and hardware aspects of the bus system.

2. Research Method
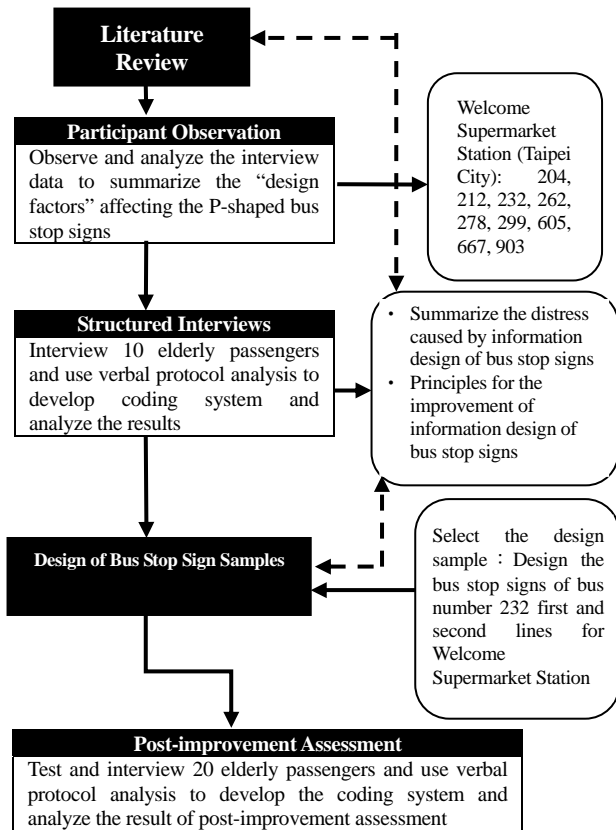
This research processes and methods shown in Figure 1

Figure 1 Research Structure

2.1. An Investigation on the Elderly's Perception of Bus Stop Signs
2.1.1. Participant Observation

First, this study used participant observation [13] to select 9 elderly subjects to perform observations and interviews in order to actually understand their reading of bus stop signs. This study selected the Welcome Supermarket Station in Taipei as the study site, and observed how the elderly took buses. After observations, this study performed simple Q&A interviews to understand how they perceived the effectiveness of information conveyed by the existing P-shaped bus stop signs, as shown in Figure 2, and whether the information meets their needs.

Figure 2 Type of Existing P-shaped bus Stop Sign

(Experimental Coding Number A)

2.1.2. Structured Interviews and Verbal Protocol Analysis

A structured interview is an in-depth interview used to analyze the data collected through participant observations. The objective of the Q&A interviews was to understand the opinions of the elderly. Therefore, this study investigated 10 different elderly subjects, as shown in Table 1.

Table 1 Basic Information of the Subjects

Case	Gender	Age	Education level	Frequency of taking bus
N1	Male	73	Elementary school	4 times per week
N2	Female	65	Junior high school	5 times per month
N3	Female	67	Junior college	Seldom
N4	Female	81	Elementary school	Seldom
N5	Male	74	Junior college	Twice per week
N6	Male	70	Senior high school/Vocational senior high school	It depends
N7	Female	82	Senior high school/Vocational senior high school	Seldom
N8	Female	72	Junior high school	Occasionally
N9	Female	77	Nil	Everyday
N10	Female	68	Senior high school/Vocational senior high school	Occasionally

The overall interview lasted for approximately 10 to 30 minutes, and were recorded and stored to facilitate the conversion of verbal data to textual data. The data collected from the interviews performed in this study were coded using verbal protocol analysis [14, 15] to develop the coding system. The coding system was applied to the factors affecting the information design of bus stop signs, as obtained from the results of "participant observations," in order to analyze the distress faced by the elderly from the information design of bus stop signs. The coding results were obtained through the various procedures of the development of the coding system, including "process of sentence punctuation," "defining and explaining coding items," and the "coding process." The coding system enabled this study to systemically arrange and analyze data to summarize the distress faced by the elderly, and design strategies for the information design of bus stop signs. The research procedures are, as follows

1) Principles and Process of Sentence Punctuation

The main principles for sentence punctuation, as the unit, were the use of spoken language in the answers to questions of the interviews. After the verbal data were converted into transcripts, the sentences were punctuated. Moreover, in the analysis on the punctuated sentences, each sentence was coded with a number to facilitate the subsequent recording

and marking, where examples are given. Upon the completion of sentence punctuation and coding, verbal data was included into the factor categories affecting the information design of bus stop signs in the next stage.

2) Definitions and Explanations of the Coding Items

This research was conducted to employ the coding for the bus stop information communication investigation based on the results of participant observation from the first stage. Factors that affect the information design of bus stop signs are classified into following five categories: For the investigation content, please refer to the details of "3. Investigation Results and Analyses".

- Identification's ability (Id): Marked stations

Bus stop signs should be identifiable. The ability to identify refers to the identification of station name, bus number, Chinese letters, Arabic numbers, and the visual senses of the elderly.

- Readability (Re): Bus helpline and traffic information

Readability refers to whether the words and sentences on a bus stop sign can be easily read and perceived, such as the use of bus information, bus helpline, and their factors, as well as the font size, font shape, line spacing, and blank spaces of the overall textual information.

- Image recognition (Ri)：Images and symbols of route map

Image recognition refers to the images and symbols on the route map of bus stop sign. This study interviewed elderly subjects in order to understand whether an abstract route map is comprehensible to them, and how are the ability to identify, and illustrative abilities of the image meanings, of symbols to the elderly.

- Viewing distance (Vd): viewing angle and viewing height

This refers to whether the viewing angle for looking at a bus stop sign conforms to the viewing height of the elderly.

- The ability in vision searching (Vr): Characteristics of information retrieval and time efficiency

This refers to the information retrieval characteristics of the elderly reading bus stop signs, as well as the time efficiency of information searching.

This study through the results of participant observation and interview of first stage is divided the factors affecting the information design of bus stop signs into two categories, **information conveyance** (C1) and **human factors** (C2)（About the analysis content, please consult the some explanation of " 3. Analysis of investigation results."）. The categories and coding framework are summarized, as shown in Table 2, and used as the coding system.

Table 2 Coding System of the Information Conveyance of Bus Stop Sign

Category	Coding Number	Classification	Factors
C1	Id	Identification ability	Marked bus stations
	Re	Readability	Bus helpline and traffic information
	Ri	Image recognition	Images and symbols of route map
C2	Vd	Viewing distance	Viewing angle and viewing height
	Vr	Ability in vision searching	Characteristics of information retrieval and time efficiency

2.2. Assessment on the Use of Bus Stop Sign with Improved Design

This stage was divided into two parts. Part 1 used verbal protocol analysis to analyze the interview data and compared the Q&A data of the interviews: The elderly were requested to look at the information conveyance of three bus stop signs, and this study compared their verbal data. Part 2 assessed the vision searching performance of the elderly: This study used the route maps of three bus stop signs to record the time that it took for the elderly to search information of a bus stop sign, and the error rate.

3. Investigation Results and Analyses
3.1. Participant Observation and Interviews

3.1.1 Investigation on the elderly's interactions with bus stop sign and design deficiencies

The results of the preliminary investigation showed that, due to the influence of experience, most elderly were satisfied with the existing bus stop signs and could accept them, most elderly expressed their distress caused by bus stop signs. For example, bus stop signs are installed too high, the font size is too small, the information in unclear, and there is no waiting seat. The elderly indicated that there are too many items included in the information conveyance of bus stop signs. In terms of the layout, they suggested that the layout is disordered and is not designed uniformly. However, due to the accumulation of experience as passengers, they were fully aware of the information content of the existing bus stop signs.

3.1.2 Effectiveness of information conveyance of items of bus stop signs and needs

1) Needs for information items of bus stop signs

The results of the interviews showed that, they expressed the highest demand for "marked stations (88.8%)" and "images and symbols of route maps (88.8%)," and expressed the lowest demand for "bus helpline (55.5%) - more than half of

them expressed this demand. However, on the contrary, elderly passengers suggested that the factor of the "bus helpline" can be ignored. Regarding "bus traffic information," the elderly were fully aware, due to their experience of bus taking. Therefore, this item was relatively unimportant. It is advised to distinguish the importance of information items in the overall layout. For example, primary information should be "marked stations" and "images and symbols of route maps," while secondary information should be "bus helpline" and "bus traffic information," to provide the elderly with the information of bus stop signs according to their needs, thus, improving the provision of services and the most adequate bus information for the elderly.

2) Effectiveness of conveyance of information items of bus stop signs

The results of the interviews regarding the effectiveness of information conveyance showed that, the effectiveness of information conveyance of "marked stations" and "bus helpline" was the highest. Most elderly suggested that the marks are clear. Moreover, the item of the lowest effectiveness of information conveyance was "images and symbols of route maps." Observations found that, the existing "images and symbols of route maps" convey more information, such as station names, road names, and traffic signs, along the route. However, as too much information is presented, the elderly will experience frequent eye movements when reading route maps. Based on the above, the font shape and size used on bus stop signs should be the same and simple. The presentation of route maps should be as simple as possible. In complicated route maps, different colors can be used to increase the ability to identify. Moreover, space or auxiliary clues can be used to highlight the station names along the route, thus, controlling the viewing range during reading, and enabling the elderly to effectively read the images of route maps.

this study divided the information of bus stop signs into two main categories, and explanations are provided, as follows:

Category 1: Information conveyance

The factors of category 1 include "bus helpline," "bus traffic information," "marked stations," and "images and symbols of route maps." This study divided these four factors into the dimension of information conveyance of bus stop signs to further understand the elderly's perceived effectiveness of the conveyance of various information items of bus stop signs, which is beneficial to studies on the design of bus stop signs for the elderly.

Category 2: Human factors

Category 2 is the dimension of human factors, including "viewing angle," "viewing height," "characteristics of information retrieval," and "time efficiency" of information searching. These factors focus on the interactions between the elderly and bus stop signs in bus stop environments. Future studies may probe into the design factors to help the elderly read and use the information functions of bus stop signs more comfortably and efficiently.

3.2. Results of Verbal Analysis

This study collected the verbal data of 10 subjects, and coded and analyzed the verbal data using a coding system developed in this study. A total of 203 punctuated sentences were obtained. According to the summary of the number of punctuated sentences in the analysis of the verbal data, this study summarized five design strategies of bus stop signs for the elderly. As shown in Table 3, the number of punctuated sentences of "image recognition" of the elderly was larger than that of (61 punctuated sentences; 30%), followed by "ability to identify (46 punctuated sentences; 22.7%)," "readability (37 punctuated sentences; 18.3%)," "ability in vision searching (35 punctuated sentences; 17.2%) in human factors," and "viewing distance in human factors (24 punctuated sentences; 11.8%)."

Table 3 Comparison on the Number of Punctuated Sentences of Five Information Items

Categories	Items	Coding Number	Number of punctuated sentences	Percentage
Information conveyance （C1）	Ability to identify	Id	46	22.7%
	Readability	Re	37	18.3%
	Image recognition	Ri	61	30.0%
Human factors （C2）	Viewing distance	Vd	24	11.8%
	Ability in vision searching	Vr	35	17.2%

4. Analysis on the Distress Caused by P-shape Bus Stop Signs and Improvement Design
4.1. Analysis on Distress Caused by P-shaped Bus Stop Signs
4.1.1. Image Recognition

The factors affecting the information design of the item "image recognition" are images of route maps, including

three sub-factors, text, colors, and images. The elderly most frequently mentioned image recognition in punctuated sentences. Image recognition mainly includes the images and symbols of route maps. This item of bus information accounts for the largest area in the layout of bus stop signs. Elderly passengers are in an area that they are unfamiliar with. The elderly would look at other station names in order from the starting station. They indicated that route map is helpful to bus taking

A route map includes text and images of points and lines. The presentation of text includes vertical, horizontal, and italic writing, and such a presentation will lead to the visual confusion of the elderly when searching for station location information. In terms of line patterns, any u-turn image will lead to the confusion of the elderly, as well as the failure to find information. The elderly indicated that the textual information of "second line," "two-section fare," and "buffer zone," renders the route map more complicated, and they could not understand such information. Regarding the explanatory table of the symbols, most elderly indicated that they did not notice it. Most suggested that the pattern of the MRT station in the route map is an interchange station. Therefore, it is necessary to highlight the "pattern of MRT stations." Furthermore, the arrow pattern of the "starting station" and the main station name, "Taipei Station," are the information patterns that passengers most frequently seek, and therefore, their recognition should be easy.

4.1.2. Identification's Ability

The factors affecting the information design regarding "ability to identify" is bus number, including the three sub-factors of text, colors, and layout. Bus stop signs are the markers of bus taking locations, During the interviews, almost all the elderly indicated that the identification and searching for a "bus number" is their primary behavior. The elderly hoped that the font size of bus numbers, such as "262 or 309," can be enlarged. However, the information with the largest font size on the existing bus stop signs is "station name," such as "Welcome Supermarket Station" or "Xingya Junior High School." The elderly said, "Passengers who are going to get off the bus need to look for the station name to avoid getting off the bus at the wrong station. However, passengers who are waiting for a bus need to look for bus numbers." Consequently, from the perspective of bus information, it is advised to highlight "bus numbers" on bus stop signs in order to increase the ability to identify.

In terms of the identification of colors, existing bus stop signs are composed of red, yellow, white, and black. The elderly indicated that red and yellow are very conspicuous and identifiable. Regarding text, the elderly suggested that black letters are clearer than red ones. Moreover, they suggested that the use of black letters on a yellow background is most conspicuous. As a whole, the elderly generally hope that color design could be simple, and the best way to increase the ability to identify is to use different colors.

4.1.3. Readability

The factors affecting the information design of the item "readability" is text, including three sub-factors, font size, font shape, and graphic and textual configuration. In terms of readability, some elderly indicated that the text is excessively complicated and unclear, and they felt distressed as it took them a lot of time to look at bus stop signs. The interviews showed that, in addition to the poor readability of route maps, the font size also led to issues when reading. The elderly all suggested that they tend to feel fatigued when reading bus stop signs, the letters on bus stop signs are too small to be seen without wearing glasses, and when wearing glasses, the letters still seem to be small and blurred. In addition, Chinese letters are complicated, and the use of different font shapes will affect reading by the elderly. A total of three Chinese font shapes are applied to existing bus stop signs. In terms of design, it is advised to use bold and round fonts with higher visual ability to identify in order to decrease the time spent on information searching by the elderly. In terms of textual layout, the presentation of text on existing bus stop signs includes vertical, horizontal, and italic. Moreover, line spacing and layout are not uniformly designed, which leads to information overload. It is advised to simplify the textual layout to conform to the reading habits of people in Taiwan in order to improve reading efficiency.

4.1.4. Viewing Distance

The factors affecting the information design of the item "viewing distance" are composed of viewing height and viewing angle. Viewing distance refers to the situation where an elderly person's viewing angle of bus stop signs conforms to their viewing height when reading. During the interviews, the elderly all indicated that existing bus stop signs are installed too high. In addition, they mentioned that they have to look up and adjust themselves to such a viewing height. The font size of bus stop signs is so small that the elderly have to spend more time reading bus information, and thus, experience soreness and pain in eyes, neck, and cervical vertebra. The elderly had to look up to read bus information;

hence, the larger viewing angle led to difficulties and deviations in reading bus information. As a result, in addition to adjusting the height of bus stop signs to the average height of people in Taiwan, the font size of textual information on bus stop signs should be taken into consideration.

4.1.5. Ability in Vision Searching

The factors affecting the information design of the item "ability in vision searching" is composed of time efficiency and the elderly's characteristics of information retrieval. Most elderly are cautious and prefer not to have rapid responses. When searching for complicated or unfamiliar information, they usually gaze at a target without visual overlap to scan the entire area. As a lot of information is included on bus stop signs, the elderly need more visual search time to look for their target information when facing unknown information. During the interviews, the elderly indicated that they may easily encounter difficulties when taking bus in a location that they are unfamiliar with. The difficulty that they encounter most frequently is missing the bus due to slow information retrieval when reading bus information. Moreover, when they are in a hurry to take a bus, they suggested that the information on bus stop signs are so disordered that they cannot find the bus information they need, as their efficiency at information retrieval is extremely low. Under such a circumstance, the elderly tend to ask other passengers waiting for bus to obtain bus information.

To effectively convey the bus information that the elderly need, it is particularly important to strengthen their ability in visual searching when facing complicated and disordered information. Most elderly look for information on bus stop signs in a specific order. As shown in Figure 3, the elderly's first target was "bus number," and then the route map below. They would look for the station name of their destination in the route map, and eventually looked at the termination and starting stations of the overall route map. The elderly's characteristics of information searching were understood. Therefore, it is advised to design route maps uniformly, and highlight the bus number, starting station, and terminal station.
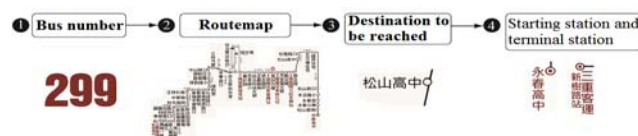

Figure 3 The Elderly's Order of Vision Searching for Bus Stop Signs

4.2. Results of Improvement Design

According to the results of the data collection and coding analysis of previous literature reviews, this study summarized the design strategies for the information design of bus stop signs as reference for the design of new bus stop signs, as shown in Figures 4 and 5:
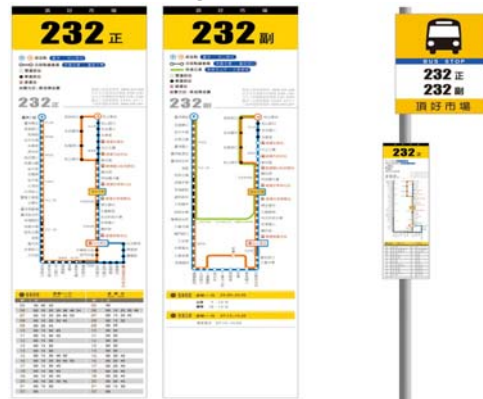

Figure 4 New Information Design I for Bus Stop Signs (Experimental No. B)

Figure 5 New Information Design II for Bus Stop Signs (Experimental No. C)

4.2.1. Images of route maps: a route map is mainly composed of "point elements: nodes and landmarks" and "line element routes." These two elements present information using a route map composed of abstractions of actual environments. The objective of a route map is to enable the elderly to identify information based on their different experiences. In a route map, where a "point element" is used for the design, organized landmarks or nodes should be used as reference points identifiable to the elderly. During the design of new bus stop signs, this study used city landmarks, such as "Taipei Station 台北車站," "Welcome Supermarket, 頂好市場" and "MRT stations 捷運西門車站," as the fixed feature element in a route map as an identifiable reference point. The changes in the fixed feature element are: Taipei Station, Welcome Supermarket Station, and MRT stations. It was intended that the use of fixed feature elements can strengthen the elderly's ability in information searching of route maps. In a route map, where "line element" is used for design, this study simplified

complicated route maps by presenting vertical lines, horizontal lines, and tilted lines at a 45 degree angle.

4.2.2. Bus number: bus number is the first information item that the elderly look for. Therefore, in addition to enlarging the font size in the design, colors with high saturation or high contrast should be used to attract attention. The brightness contrast ratio of images to text should be 5:1. Moreover, the bus number should be placed in an area of the layout that can catch the eye, which enables the elderly to identify it at a far distance.

4.2.3. Text: the text used in previous bus stop signs is inconsistent. The font shapes include bold font, standard Kai font, and calligraphy font. This study used consistent bold and round fonts to present the textual information in order to decrease the time spent on searching by the elderly. In terms of the textual information of route maps, the font size of station names in previous route maps is inconsistent, which leads to excessively crowded line spacing and layout, and presents the elderly with difficulties in information searching. To resolve such distress, the line spacing of new bus stop signs is maintained, while the textual layout in the route map is simplified to improve reading efficiency.

4.2.4. Viewing height and viewing angle: one of the new bus stop signs, as designed in this study, conforms to the viewing height of the elderly. This new bus stop sign was installed according to the average height and accurate viewing angle of the elderly, with the intention of reducing the difficulty and deviation in reading bus information. The other design retained the human factors/behaviors of previous bus stop signs. The height of bus stop signs is the same as previous signs. The objective of this design is to retain the existing perceptions of the elderly, rather than change it because of the information content of new bus stop signs. Therefore, only the information content in this design was changed, while the height of the bus stop sign remained unchanged.

4.2.5. Time Efficiency and Characteristics of Information Retrieval: owing to the frequency of bus services, it is necessary to efficiently retrieve bus information required when reading bus stop signs. Therefore, the same category of information should be designed in the same manner in the layout. The area of information presentation in a layout should be adjusted according to the importance of the information item in order to reduce the time spent on visual searching. Moreover, the elderly will make decisions intuitively, according to their former perceptions, when facing complicated and large amounts of new information. Considering their stubbornness, in the new bus stop signs, this study used the same layout and color configuration as those of previous bus stop signs to enable the elderly to more rapidly adjust themselves to the information content of new bus stop signs.

5. Investigation on the Improvement Bus Stop Signs

In the post-improvement assessment, the elderly were first requested to look at various information of existing bus stop signs (experiment No. A, Figure 2), and two amended bus stop signs (experiment No. B and C). Verbal protocol analysis and interviews were used to obtain the results under the mutual influence of different visual conditions. The assessment was divided into two parts: Part 1 offers a comparison on the Q&A data; Part 2 shows the performance of visual searching.

5.1. Comparison on Q&A Data

5.1.1. Test Result of Experiment No. A

Experiment No. A was the existing Welcome Supermarket Station bus stop sign. The verbal protocol analysis showed that the largest number of suggestions was provided on the punctuated sentences of route maps of bus stop signs. The elderly suggested that the route map is excessively curved and complicated. Therefore, they could not successfully search the station names along the route. As a result, some elderly would associate their own memories with the route map. Verbal protocol analysis found that there was a significant difference in the perceptions of route maps between male and female elderly. Elderly males suggested that the route map with curves and directions could help them predict the route and direction of the bus, and they like to grasp the directions of the route map. However, elderly females preferred using the simplified route map.

5.1.2. Test Result of Experiment No. B

Vertical writing was used in the information layout of experiment No. B, and bus station location and route information were placed in different layouts (upper and lower, respectively). Verbal protocol analysis showed that, most elderly were most satisfied with this bus stop sign, as the layout is simple and comprehensible, the color is clear, the arrangement is ordered, and readability is high. While they suggested

that the straightened and simplified route map is more comprehensible, they also suggested that they are not used to the arrangement of front and back sides, and suggested that the layout of bus stop signs could be widened to enable the presentation of these two kinds of route information on the same side to facilitate reading.

3) Test Result of Experiment No. C

Two colors of arrows were used in the route map of experiment No. C, which can help most elderly understand the directions of route maps and engage in the visual searching for station names. Some elderly also mentioned that the images of two-way and one-way stations in the route map are incomprehensible. Moreover, some elderly suggested that the use of a single color, black, made the route map simpler, clearer, and neater, and the presentation of a larger layout can better facilitate reading.

5.2. Visual Searching Performance of the Elderly
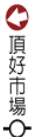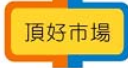
During the assessment of visual searching performance, the elderly were first requested to read the route maps of bus stop signs, and then this study conducted three tests to assess the elderly's visual searching performance, in order to understand whether the information of these three route maps provides the elderly with the opportunity to learn and adapt themselves to bus stop signs. The assessment was divided into two parts: Part 1 assessed the time efficiency of information retrieval of route maps; Part 2 assessed the number of correct answers in the Q&A session of testing the information conveyance of the route maps of three bus stop signs to understand the error rate of information retrieval of route maps.

5.2.1. Testing the Image of Bus Taking Locations in Route Maps

The image of a bus taking location, which is the location for taking a bus, is very important in a route map. Before taking a bus, the elderly have to first understand the bus taking location, and could extend from this map to the destination they intend to visit. There was a significant difference in both the correct answer rate and searching times for the three bus taking location images used in this test. The correct answer rate of experiment No. A was significantly lower than that of

experiment No. B and C. The time spent in information searching of experiment No. A was also significantly higher than that of experiment No. B and C (as shown in Table 4). The results showed that the route map of bus stop sign experiment No. A is more complicated and disordered, leading to an increased time of information searching for the elderly. Experiment No. B and C are the bus stop signs re-designed in this study. As a route map includes complicated bus information, the graphic and textual configuration of black letters on a yellow background should be used to increase the ability to identify bus taking location images in a route map. The test results showed that, the answer rate of experiment No. B was the highest, and the searching time was the shortest, as the viewing height of experiment No. B was reduced.

Table 4 Average Number of Seconds and Number of Correct Answers of the Test Sample of Bus Taking Location Images（welcome supermarket stop）

Test Items	xperimental No：A	Experimental No：B	Experimental No：C
Images of sections in buffer zone	頂好市場	頂好市場	頂好市場
Time of retrieval/average number of seconds	10.45 sec	5.15 sec	7.66 sec
Number of subjects with correct answer	8	18	16

5.2.2. Test on the Route Anchor Points of Route Map

The test on route anchor points requested the elderly to point out the route from Songshan Station to Huai Sheng junior high school in order to determine their visual searching ability of route maps. The interviews showed that, the correct answer rate of experiment No. A was the lowest, as the bus stop sign was installed too high to be seen by the elderly. Moreover, the correct answer rate of experiment No. B was the highest during testing. The elderly's failure to find the anchor points was caused by black arrows. As a result, the elderly would hesitate to look for routes and have no idea which color of route to take (as shown in Table 5).
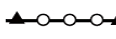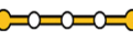
Table 5 Average Number of Seconds and Number of Correct Answers of the Test on Anchor Points of Route Map

Test Items	xperimental No：A	Experimental No：B	Experimenta l No：C
Images of sections in buffer zone			
Time of retrieval/avera ge number of seconds	9.70 sec	7.55 sec	8.40 sec
Number of subjects with correct answer	5	13	9

5.2.3. Test of the Images of the Buffer Zone of a Route Map

In verbal protocol analysis, the elderly mentioned that the use of single color (black) triangles to mark the sections in the buffer zone of experiment No. A (0 subjects with correct answer), and the excessively long viewing distance, caused by its height, made it difficult to understand and read the information. In experiment No. B (6 subjects with correct answer), although there was a significant difference in the hue and brightness of colors in the buffer zone (where blue and orange were used to denote the routes and compass of the black sections), most elderly still could not identify the buffer zone. The reason why some could identify it was that the height of the bus stop sign was reduced. In experiment No. C (9 subjects with correct answer), although the viewing height was the same as that of experiment No. A, the simple use of the high contrast between yellow and black to mark the sections of the buffer zone made the number of correct answers significantly larger than that of those in experiment No. A at the same height (as shown in Table 6).

Table 6 Average Number of Seconds and Number of Correct Answers in the Test on Images of Sections of Buffer Zone

Test Items	xperimental No：A	Experimenta l No：B	Experimenta l No：C
Images of sections in buffer zone			
Time of retrieval/avera ge number of seconds	—	8.76 sec	9.43 sec
Number of subjects with correct answer	0	6	0

5.3. Analysis of the Post-improvement Assessment

The overall tests and assessment to compare the information conveyance of the three bus stop signs for the elderly found that, most elderly indicated that the ability to identify, readability, image recognition, viewing distance, and ability in visual searching of experiment No. Bwere the best among the three bus stop signs(as shown in Table 7).

The results showed that the information conveyance effectiveness of experiment No. B was the best for the elderly among the three bus stop signs. The interviews on the factors (including route map, bus number, text, viewing height, viewing angle, time efficiency, and characteristics of information retrieval) affecting the information design found the difficulties encountered by the elderly, and their preferences. The results are summarized in Table 8.

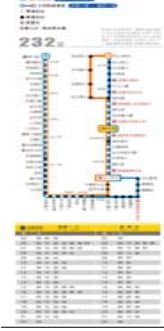**Table 7 New Information Design I for Bus Stop Signs (Experimental No. B)**

Route map	bus number	Text

Table 8 Results of Information Conveyance of Bus Stop Signs

Classificatio n of Items	Factors	Test Results
mage recognition （Route map）	Text	• The spacing of 15-20pt below the horizontal eye line can be better recognized. • The spacing of 20-25pt beyond the horizontal eye level can be better recognized. • Round and bold fonts can be better recognized. • Text presented in the same direction can be better recognized.
	Color	• Lines of two colors can be better recognized. • In terms of the image-text of a symbol or image, the presentation of black letters on a yellow background can be better recognized.
	Images	• Route maps composed of horizontal lines, vertical lines, and tilted lines at a 45 degree angle can be better recognized. • Arrow symbols, as directions in a route maps, can be better recognized.

Identification's ability (bus number)	Text	• Bold font can be better recognized. • Font size of 130-190pt can be better recognized.
	Color	• Black letters on a yellow background can be better recognized.
	Graphic and textual configuration	• The marked "bus image" can help the elderly identify bus numbers. • It is preferable to place the bus number alone at the top of the bus stop sign.
Readability (Text)	Font size	• The font size of 15-25pt can be better read.
	Font shape	• Round and bold fonts can be better read. • It is preferable to highlight important information in boldface text.
	Graphic and textual configuration	• It is preferable to reduce text information, which will not affect the perception of bus information. • For the text in a route map, the line spacing of 1.0 is better.
Viewing distance	Viewing height and angle	• It is preferable to install a bus stop sign at the height of the average horizontal eye level of the elderly. • The layout should not be taller than 15-20 of the horizontal eye level of the elderly.
Ability in visual searching	Time efficiency and characteristics of information retrieval	• A route map should account for more than 50% of the area of the layout in order to improve the efficiency of information retrieval. • Information searching efficiency will be improved after the same category of information is designed in the same manner. • Visual searching efficiency will be improved if the route map is placed in the center of the layout of the bus stop sign.

6. Conclusions

With the changes of lifestyle, the demands of going out and getting around for the elderly have gradually been gaining attention. Currently, in Taiwan most cities don't have mass rapid transit systems. Outdoor movement could only be achieved using public transportation systems like buses which are in the majority of these cities. This research was focused on the behavior toward bus riding and investigated the information conveyance and the use of the bus stops by the elderly in Taiwan. By studying the efficiency of the information conveyance of bus stop signs at their present stage and then revising the current drawbacks we come up with faults that can be rectified. Experimental investigation will be conducted and we expect to find reasonable information about bus stops for the elderly when they want to ride a bus.

Currently, the digital development trend of Metropolitan bus stop has evolved and is evolving, but has still not popularized. P-type bus stops are still commonly used and the elderly still rely on the bus stop for providing information to ride the bus. Previous research indicated that reading the bus information was a major burden to the elderly. Current road maps are drawn according to bus routes which do not help elderly in recognizing relations between the stations. As a result, the current information presentation of a p-type bus stop approach is not conducive to the elderly. Although numerous researches have been studied from the aspects of layout choreography, text, color, image and, visual relationship, this research would conduct an empirical study and design verification on information conveyance of bus stop signs for information collection, image design, and location design according to the elderly reading behavior. Moreover, by considering the human factors of the elderly we can understand the characteristics of living cultural behavior and information extraction of elderly in Taiwan. As a matter of fact, we could solve most of the problems of bus riding information and then come up with humanized, secured, comfortable, and convenient bus stops

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