Establishing a Cognitive Map of Public Place for Blind and Visual Impaired by Using IVEO Hands-On Learning System

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Abstract. In recent years, there has been an escalation of orientation and way-finding technologies and systems for the blind visually impaired people. The purpose of this study was to help visual impaired to access and explore spatial information by establishing a cognitive map of public place using IVEO hands-on learning system and tactile direction map. The IVEO hands-on learning system combines touch, sound, and sight, using touch and sound learning modalities to help the blind and visually impaired to learn faster and retain information longer, meanwhile making learning more interesting and interactive. Subjects were divided into four groups in terms of route familiarity and IVEO Aids of exposure, with an equal number of subjects (N=4) in each group. Then, the subject performed an actual Way-finding test to get back and forth between Ximending and TDTB (Taiwan Digital Talking Books association). The dependent variables were total time, number of miss route, and number of request. The results revealed a significant effect of IVEO Aids, and the subjects could perform better through IVEO Aids. This research provided a learning method of orientation and mobility for the blind and visually impaired, and assisted them to be familiar with the route safer and faster.

Keywords: Learning System, audio-tactile maps, cognitive map, Way-finding, blind people.

1 Introduction

1.1 Background and Motivation

According to the statistics by the Ministry of Interior, Taiwan, the legal population of the visually impaired increased from 44889 persons in 2002 to 56589 persons in 2012 in Taiwan. The population of the blind and the visually impaired has been increasing sharply over the past 10years. (Taiwan Ministry of the Interior, 2012).

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In an alien environment, the sighted adult usually need a map to find spatial information while a tactile direction map is required for the blind and visually impaired (Levine, 1982; O'Neill, 1999; Klippel, Freksa & Winter, 2006).

The blind and visually impaired can successfully use verbally presented route information as well as survey information in constructing cognitive maps of environments, even if they are not as efficient as normally sighted people (Steyvers and Kooijman, 2008).Thus audio-tactile maps, which allow a multi-modal co-comprehension of tactilely perceived and verbally presented information, are a promising way to diminish some restrictions of tactile maps.

1.2 Objectives

The IVEO hands-on learning system combines touch, sound, and sight, using touch and sound learning modalities to help the blind and visually impaired to learn faster and retain information longer, meanwhile making learning more interesting and interactive (Gardner, 2006). We propose assistive technology system to aid in way-finding based on IVEO hands-on learning system. The participants who learned the route by using IVEO Aids and tactile direction map showed a more accurate level of confidence in retrieving the spatial information necessary to complete the way-finding. The IVEO hands-on learning system is shown in Figure 1.

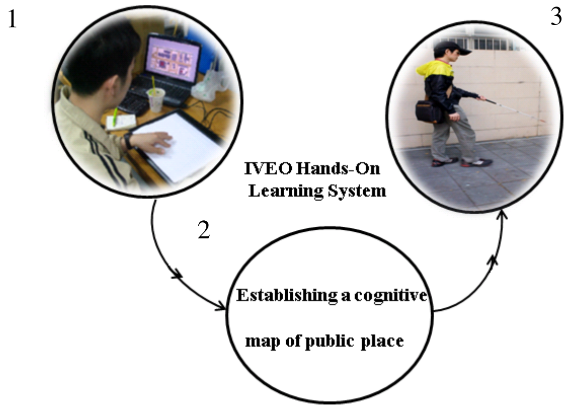

Fig. 1. The IVEO hands-on learning system

Tactile maps can also be an extremely effective tool for representing spatial information for the orientation and mobility (O&M) student (Bentzen, 1997). Blades et al. (2002) found that the performance of visually impaired people can be enhanced by the strategies used for learning a new route, e.g. by modeling a map of the route itself. However, many orientation and mobility (O&M) counselors dedicate a great portion of their lesson preparation time to the founding of detailed tactile maps to be used only once or twice by the student. An IVEO creator software and View-Plus Embosser for producing highly detailed, “one-off” maps would be of great advantage to these counselors and their students, freeing the counselor's time for actual O&M counselor, instead of the difficult task of tactile cartography.

2 Research Method

2.1 IVEO Hands-On Learning System Interface Design

Automatic tactile-audio map creation is the key component of our proposed interactive solution. The step takes a single map image as input and generates output image for easy tactile reproduction and an SVG file which combines graphical contents with audio annotations. We applied the mainstream graphics software, such as Google Sketch Up to design the map image, and interviews and questionnaire were designed to identify the requirements that support the blind and visually impaired for Way-finding activities. Moreover, use IVEO creator software to input the title and content to customize tactile map. In addition, View-Plus Embosser was used to print the tactile map and place it on the IVEO touchpad so that the users can press different areas of the map to hear the titles and content spoken back to them. The Processing flow of the IVEO System Interface Design in Figure 2.

2.2 Experimental Design

The primary criterion for subjects selection was that they are the blind visually impaired people. Moreover, they have experience to walk alone in the streets. The subject was asked to fill out a SDQS/sense of direction questionnaire-short form which elicited information concerning his cognitive map, sense of direction, spatial memory, familiarity and uniform into four groups accordance with scores. The independent variables were route familiarity (low or high) and IVEO Aids of exposure (with or without). The low familiarity was defined as one practice of walking from Ximending to TDTB before proceeding Way-finding test, and the high familiarity was defined as three times practices of walking from Ximending to TDTB.

A total of 16 visually impaired participated in this experiment, and the subject was assigned to one of four groups in combination of experimental variables, familiarity and IVEO Aids of exposure, with an equal number of subjects (N=4) in each group. R1 group is low route familiarity and without IVEO Aids, R2 group is high route familiarity and without IVEO Aids, R3 group is low route familiarity and with IVEO Aids, R4 groups is high route familiarity and with IVEO Aids. The dependent variables were total walking time, number of miss routes, and number of requests.

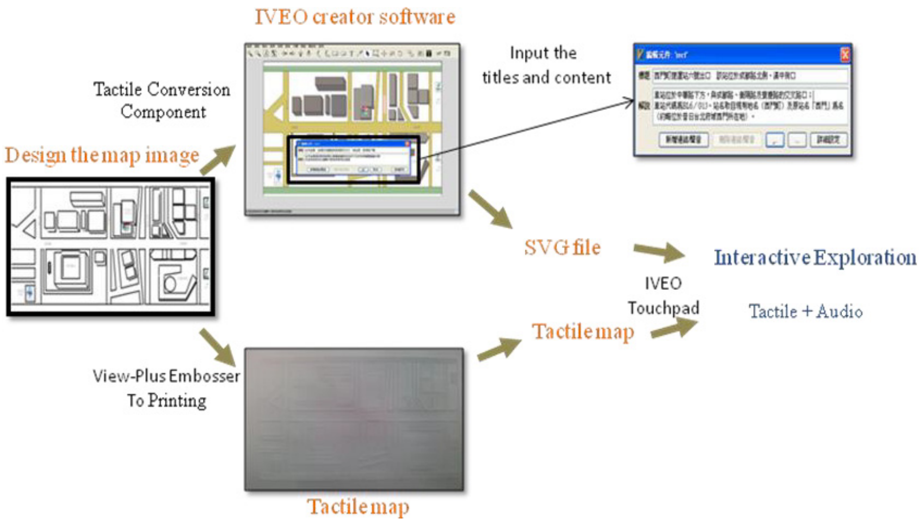

Fig. 2. Processing flow of the IVEO System Interface Design

2.3 Experimental Procedure

The experiment took around 3 hours, following steps:

1. The subject was asked to fill out a SDQS/sense of direction questionnaire-short form.
2. The subject performed a Way-finding test from Ximending to TDTB (Taiwan Digital Talking Books association). Data collected primarily by two experimenters. One was a cameraman who recorded all the scenes with a video camera along the way. Another logger registered behaviors of the subjects and record his/her specific activities.
3. Following the test, subjects were interviewed and asked to fill out NASA-TLX questionnaire and interviewed for approximately half an hour about their mental workload.

3 Experimental Results

3.1 Number of Missed Routes

Analyses of variance were used to detect significant difference among variables. Table 1 showed two-way ANOVA results of number of missed route. There was a significant effect of IVEO Aids on number of missed route ($p<0.05$), but the effect of route familiarity was not significant. It means that with the IVEO Aids in actual Way-finding test, the Number of Missed routes of subjects would decrease significantly.

Table 1. Two-way ANOVA on number of miss routes

Source	DF	SS	MS	F	P
IVEO Aids	1	45.563	45.563	8.64	0.012*
Route Familiarity	1	22.563	22.563	4.28	0.061
Interaction	1	5.063	5.063	0.96	0.346
Error	12	63.250	5.2708		
Total	15	136.438			
S = 2.296 R-Sq = 53.64% R-Sq(adj) = 42.05%					

*p<.05.

3.2 Number of Requests

Likewise, number of requests were calculated during the experiment. Table 2 showed two-way ANOVA results on number of request. There was a significant effect of IVEO Aids on number of requests (p<0.05), and the effect of route familiarity was also significant (p<0.01).The route familiarity and IVEO Aids for the number of requests is of decisive importance in actual Way-finding test.

Table 2. Two-way ANOVA on number of requests

Source	DF	SS	MS	F	P
IVEO Aids	1	9	9	8.64	0.012*
Route Familiarity	1	12.25	12.25	11.76	0.005**
Interaction	1	4	4	3.84	0.074
Error	12	12.5	1.0417		
Total	15	37.75			
S = 1.021 R-Sq = 66.89% R-Sq(adj) = 58.61%					

*p<.05 **p<.01.

3.3 NASA-TLX

Subjects were asked to fill out a NASA-TLX questionnaire for measuring the mental workload. According to the score of each item, the differences of mental workload in these subjects were evaluated. Table 3 showed two-way ANOVA results of NASA-TLX. The result could help us to evaluate the mental workload for cumulative learning effect. There was a significant effect of IVEO Aids on NASA-TLX score(p<0.01) that mental workload of subjects would decrease significantly by IVEO Aids, and the effect of route familiarity was also significant (p<0.05).

Table 3. Two-way ANOVA on score of NASA-TLX

Source	DF	SS	MS	F	P
IVEO	1	2620.08	2620.08	46.69	0.000**
Route Familiarity	1	369.73	369.73	6.59	0.025*
Interaction	1	240.04	240.04	4.28	0.061
Error	12	673.47	56.12		
Total	15	3903.32			
SS = 7.491 R-Sq = 82.75% R-Sq(adj) = 78.43%					

*p<.05 **p<.01.

4 Conclusion

We can find significant effect of using IVEO Hands-on learning system for the blind and visually impaired. Thus subjects could perform better through IVEO Aids in terms of IVEO Aids and route familiarity. This research provided a learning method of orientation and mobility for the blind and visually impaired with orientation and mobility (O&M) counselors, and assisted them to be familiar with the route safer and faster.

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