Goods-Finding and Orientation in the Elderly on 3D Virtual Store Interface: The Impact of Classification and Landmarks

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Absract. The internet 3D virtual store has received wide attention from researchers and practitioners due to the fact that it is one of the most killing applications customers can feel in a real shopping environment and possibly increase satisfaction. Though numerous studies have been performed on various issues of the internet store, some research issues relating to the spatial cognition of the elderly when immersed in a 3D virtual store still await further empirical investigation. The objective of this study was to examine how elderly users acquire spatial cognition in an on-screen virtual store. Specifically, the impact of presence and absence of goods-classification on the acquisition of route and survey knowledge was examined. Since landmarks are associated with both route and survey knowledge, we expected to observe the impact of different types of landmarks with both presence and absence of goods-classification. The experimental results indicated that the presence of goods-classification was more important in constructing route knowledge than in absence, and the time of duration of goods-finding would be shorter. However, we also found that the measuring scores of survey knowledge in presence of goods-classification were not significantly larger than in absence. In addition, the measuring scores of route knowledge were the largest and the time of duration of goods-finding was shorter while the presence of goods-classification combined with landmark in the type of alphanumeric + 2D picture + 3D object. Simultaneously, it could be found in absence of goods-classification. Therefore, while the goods-classification is absent, the landmarks could be seemed as redundant codes for goods-finding in 3D virtual store.

Keywords: 3D virtual store, Goods-finding, Goods-classification, Landmarks, Route knowledge, Survey knowledge.

1 Introduction

The internet store has received wide attention from researchers and practitioners due to the fact that it is one of the most killing applications for customers to buy any

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things on the Internet. It lets us buy what we want, when we want at our convenience, and helps us to imagine ourselves buying, owning, and having positive outcomes by the goods available out there on the web [6]. Shopping has been a way of identifying oneself in today's culture by what we purchase and how we use our purchases. Online shopping has been quiet popular nowadays since its first arrival on the Internet in society. Although the percentage of older adults (i.e. silver tsunami) using the web is less than the percentage of younger individuals, surveys indicate that this may not be the case for long. The World Health Organization estimates that by the year 2020, 24% of Europeans, 17% of Asians, and 23% of North Americans will be over the age of 60 [32]. By 2020, the world will have more than 1 billion people age 60 and over. The older population is growing rapidly worldwide and is becoming an increasingly important demographic to understand. According to Coyne and Nielsen [4], there are an estimated 4.2 million Internet users over the age of 65 in the United States. This number will continue to grow internationally at a rate that reflects the overall population trends previously discussed.

However, most internet stores adopt letters, two dimensional (2D) pictures, voice and cartoons to display goods, which are short of the intuition of goods and systems do not support interaction with the goods [8]. It would influence the customers' real shopping experience; what's more, it minifies the shopping desire of the customers. These problems can be solved by utilizing the technology of virtual environments (VEs). In Web-based virtual environments, scenes and physical images can be compressed and transferred through network with limited bandwidth and 3D scenes of goods can be built on the web using some newest techniques. This technology allows the simulation of 3D VEs on a computer: humans can experience those environments by active exploration [11]. In 3D virtual store there provides a computer-synthesized world in which users can interact with goods and perform various activities. Although 3D virtual store improves the sense of reality and interaction with goods, there are some issues need to be discussed. Generally in large-scale VEs, the user's viewpoint cannot encompass the entire environment [26]. In such VEs, navigation is a fundamental activity, and successful use of the VE requires that the user be able to easily and efficiently navigate from one location to another [5]. However, previous researches have shown that users of VEs are often disoriented and feel lost in hyperspace. Therefore, users often have extreme difficulty in completing navigational tasks [3][7]. It also has the same problems in 3D virtual store. Although the 3D virtual store is characterized by on-screen small-scale virtual environments, the user has an egocentric viewpoint that is within the environment, and it visually affords the experience of movement, rotation, and changing the elevation of the view in such environment [29]. In conventional grocery store, it is often divided into several areas or rooms, each built around a particular shopping theme [27]. Of course, in 3D virtual store, the store layout is also built for helping customer easier to browse. Sometimes the destination is not immediately visible. Such can be the case also with the typical on-screen virtual environment which may include, for example, walls that make up internal rooms and corridors visually obscuring the destination [21]. Therefore, the human spatial abilities that influence their acquisition and usage need to explore, particularly when interacting with such environments. Those abilities, in the 3 D virtual store, consist primarily of orientation and goods-finding. Additionally, previous studies on cognitive aging have found that certain aspects of human information processing abilities are negatively correlated with age [20]. Specifically, Park summarized four basic mechanisms accounting for age-related decline in cognitive functions, including processing speed, working memory, sensory function and inhibition. Lin found that older people were more likely to get disoriented in hypertext perusal and they also failed to browse the document as broadly as young adults could [16]. Neither did the aged people manage to retain browsed information as accurately as their young counterpart even when assisted with multimedia presentations. In view of this trend, there is an increasing need to investigate and better understand the abilities of orientation and goods-finding in the elderly, particularly when interacting with a 3D virtual store.

In general virtual environment, the ability of orientation influences the efficiency and effectiveness of wayfinding. Wayfinding is a term that can refer to a rather narrow concern: That is, how well people are able to find their way to their particular destination without delay or undue anxiety [23]. It is knowing where you are in a building or an environment, knowing where your desired location is, knowing how to get there from your present location, and used in the context of architecture to refer to the user experience of orientation and choosing a path within the built environment. Travelers find their way using landmark knowledge, route knowledge, and survey knowledge [18]. The first two types of knowledge are more specific knowledge representing sensory experience [14]. Landmark knowledge records the visual features of landmarks, including their shape, size, texture, and so forth [10]. For a structure to be a landmark, it must have high imageability; that is, it must be distinctive and memorable [17]. Most often, landmark knowledge is an acquired first when encountering and learning to know a new and unfamiliar environment. The recognition of landmarks becomes a part of the construction of route knowledge, where the landmarks are the points that make up the routs. Later, landmarks are the objects and elements in the survey knowledge and they are part of constructing the layout and relational configuration of the elements in the environment [2][30]. Survey knowledge provides a map-like, bird's-eye view of a region and contains spatial information including locations, orientations, and sizes of regional features [9]. Each type of knowledge helps the traveler construct a cognitive map of a region and thereafter find their way using that map [1][22]. In study of orientation, the notion of a "cognitive map" has received much research attention [13][19]. At its most general, a cognitive map is a mental construct which we use to understand and know the environment [12]. The term assumes that people store information about their environment which they use to make spatial decision [13]. Because of the importance of landmark knowledge for constructing a cognitive map, much research was devoted to the impact of landmarks on orientation. Several researchers have studied the value of 2D landmarks (i.e. textual and 2D images) for wayfinding. Witmer et al. used verbal directions and photographs to study route learning [31]. Waller et al. applied cardboard numeral, images of stuffed animal and arrow to study real-world task training and found that long exposure fostered good spatial knowledge under several VEs [28]. Additionally, several researches have been done on the effects of 3D landmarks for wayfinding. Elvins found that 3D thumbnails make better guidebooks for 3D worlds than do text and 2D thumbnail images [9]. Parush and Berman discussed the impact of navigation aids and 3D landmarks on the acquisition of route and survey knowledge in spatial cognition and found that combined impact of both the navigation aids used in the learning and the presence of 3D landmarks was primary evident in the orientation task [21].

Although each of these studies recognized the value landmark knowledge for wayfinding, none studied the value of combination of 2D and 3D landmarks in familiarizing travelers within a virtual environment. In addition, the environment of 3D virtual store is a small geographical area. We are interested in the efficiency and effectiveness of goods-finding, not wayfinding. The showrooms in the store could be considered as blocks in the map and the cabinet in the showroom as the buildings in the block. So the landmarks should be also important for user to construct a "cognitive map" on goods-finding in 3D virtual store, and there are some different types of landmarks could be applied, such as 3D object, 2D image and alphanumeric icon.

In addition to landmarks, the goods-classification should be another cue for goods-finding. Goods-classification divides goods into some classes by natures or trademarks, and allows people to seek a good appropriately from these classes. Whether the combined impact of both the goods-classification and different types of landmarks (i.e. alphanumeric, 2D image and 3D object) are significant for good-finding in the elderly within the 3D virtual store or not? This is a primary goal of our study. Therefore, the objective of this study was to examine how elderly users acquire spatial cognition in an on-screen virtual store. Specifically, the impact of different types of landmarks on the acquisition of route and survey knowledge was examined. In addition, their combined effect with the presence or absence of goods-classification was also examined. If goods-classification is associated more with the acquisition of spatial knowledge, we expected to observe its greatest impact during the goods-finding. Since landmarks are associated with both route and survey knowledge, we expected to observe the impact of different types of landmarks with both presence and absence of goods-classification.

2 Method

2.1 Participants

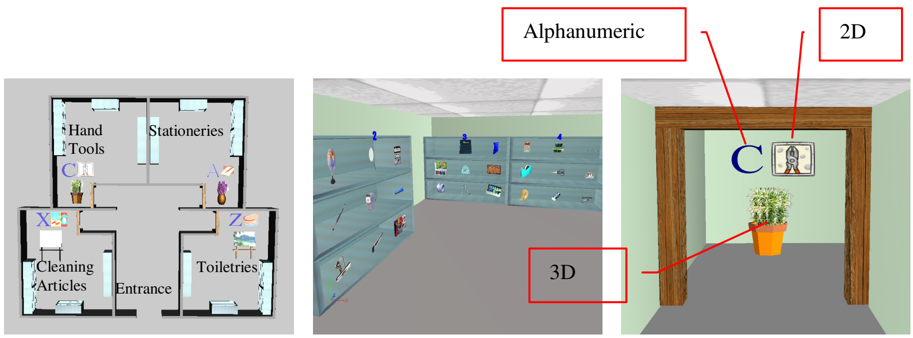
There were 32 people (average age of 69.5 years) selected to participate in the experiment. They were paid a nominal NTD500 as compensation for their time. All participants were fully informed and had signed a consent form. Some researchers found that repeated exposure to the same virtual environment with separation of less than seven days could significantly affect the levels of cybersickness which would induce participant's disorientation and nausea [25][15][24]. Therefore, the participants had not been exposed to the experimental VE in the previous 2 weeks.

2.2 Apparatus and the VE

The VE experiment was constructed using a virtual environment developing software (MAYA and Virtool) and presented on a 19" TFT-LCD display. The scene was designed as a retail store which contained four showrooms. There were two conditions to be designed. One condition was that the store was divided into four subject showrooms including stationeries, hand tools, cleaning articles and toiletries as shown in Figure 1. The other was just divided into four showrooms, not classified. The landmarks in the specific 3D environment were highly visual and salient with a unique shape and volume in contrast to the goods. The landmarks were typical home and office objects such as a painting, a metaphor picture, a flowerpot and others.

2.3 Experimental Design and Procedures

The study involved a 2 (Goods classification: absence or presence) × 8 (Types of landmarks: none, alphanumeric, 2D, 3D, alphanumeric + 2D, alphanumeric + 3D, 2D + 3D and alphanumeric + 2D +3D) between-subjects experiment, resulting in a full-factorial design with 16 treatment conditions. Each participant was randomly assigned one of the eight conditions of landmarks in presence or absence of goods-classification to do the task of goods-finding. Therefore, there were two participants was randomly assigned to one of the sixteen conditions. In other words, there were two participants assigned to each condition.



(a) A top view of the experimental 3D store

(b) A view of the stationery room

(c) Three types of landmarks are presented in the hand tools room

Fig. 1. The 3D virtual environment of the retail store

During the exposure period, participants were asked to search for and confirm some goods in the store. There were eight target goods, two in each showroom, need participants to search for. When they found the target, s/he should move the cursor on the object and click the left button of mouse twice to respond ‘hit.’ There were four stages in the experiment. In each stage, participant was randomly assigned two target goods to find and asked to attempt to recall the location of target goods and complete an oral questionnaire of route knowledge when two target goods had been found. When all eight target goods had been found, s/he was asked to complete a questionnaire of survey knowledge.

2.4 Measurements

Spatial knowledge and performance measurements were recorded and collected for all trials. The measurements included the following:

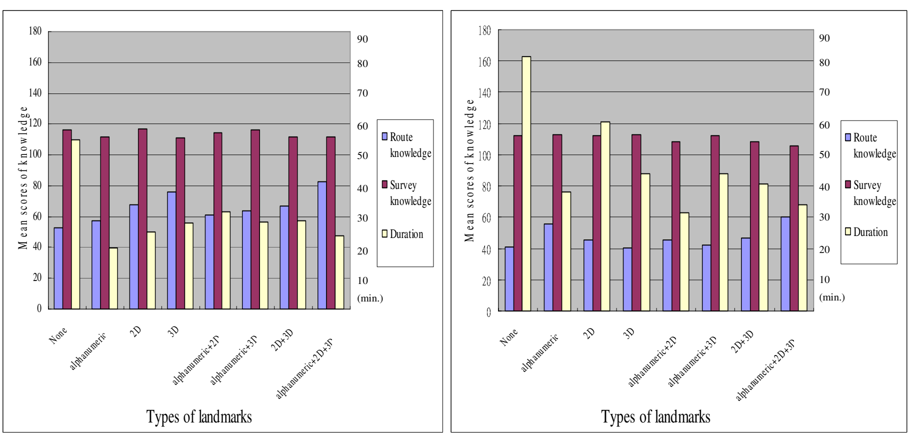
1. Measurement of route knowledge: When participants finished two goods finding and returned to the entrance in each stage, they were requested to complete an oral questionnaire to describe the correct position of one of the two target objects. Participants would receive 9 points if they were able to point out the correct showroom, 6 points if they were unable to point out the showroom but the next door and 3 points the next to next door; 7 points if they were able to point out the correct cabinet where the target object was posited, 5 points if they were unable to point out the cabinet but the next door and 3 points the next to next door; 5 points if they were able to point out the correct shelf where the target object was posited, 4 points if they were unable to point out the shelf but the next door and 3 points the next to next door.
2. Measurement of survey knowledge: When participants finished all eight goods finding, they were requested to point out the correct position of all eight goods on the map. The calculation of scores was the same as route knowledge.
3. Goods-finding duration: The time from beginning of the trial until the Entrance key was pressed indicating the end of the trial.

3 Results and Discussion

This experimental study was designed to investigate the impact of presence and absence of goods-classification on the acquisition of route and survey knowledge and the effects of different types of landmarks with both presence and absence of goods-classification. The score analysis in the route knowledge revealed that the presence of goods-classification was significantly better than in absence ($F_{1,16}$ = 25.20, P = 0.000). However, the F for survey knowledge was not statistically significant ($F_{1,16}$ = 2.99, P = 0.103). The time of goods-finding in presence of goods-classification was also significant shorter than in absence ($F_{1,16}$ = 30.98, P = 0.000). In addition, the scores of route knowledge with landmarks in presence of goods-classification were significant larger than in absence ($t_{(26)}$=4.69, P=0.000) and the time of duration of goods-finding was also significant shorter ($t_{(26)}$=4..85, P=0.000). These results showed that the goods-classification was positive and important for the acquisition of route knowledge and good-finding. When the participant had more route knowledge, the time of duration of goods-finding would be shorter. While the route knowledge was constructed, the survey knowledge was also made up but slowly. Goods-classification and landmarks were good help for spatial knowledge in the beginning, especially in route knowledge. After the learning phase, the survey knowledge would be made up clearly even though the goods-classification and landmarks were absent. Therefore, the time of duration of good-finding in the forth stage was shorter than the first stage. Because the survey knowledge was measured when experiment finished, the scores of survey knowledge were not significantly different on the means of each condition.

In effects of landmarks, we found that different types of landmarks were not significantly different in acquisition of route knowledge ($F_{7,16}$ = 1.74, P = 0.169) and survey knowledge ($F_{7,16}$ = 0.61, P = 0.741). However, in comparing the difference between the presence and absence of landmarks, we found that the scores of route knowledge in presence of landmarks were significantly larger than in absence when goods-classification was present ($t_{(26)}$=4.78, P=0.000) and absent ($t_{(26)}$=2.59, P=0.008), and the time of duration of goods-finding was also significantly shorter for participants that navigated with landmarks as compared to without landmarks in presence ($t_{(26)}$=22.14, P=0.000) and absence ($t_{(26)}$=13.65, P=0.000) of goods-classification. The scores of survey knowledge were significantly different between presence and absence of landmarks in presence of goods-classification ($t_{(26)}$=2.27, P=0.016), but not significant different in absence of goods-classification ($t_{(26)}$=1.19, P=0.123). It can be seen that landmarks were also important for goods-finding in 3D virtual store, no matter what combined type was used. This finding is in agreement with many previous studies indicating the impact of landmarks on spatial cognition. The finding also reflects the more advantage of having landmarks in the 3D virtual store environment particularly when goods were classified.

According to the previous results, goods-classification is associated more with the acquisition of spatial knowledge. Finally, an additional analysis was performed to evaluate what type of landmarks would be the greatest impact in goods-finding while the goods-classification was present. Figure 2 displays the mean scores of route and survey knowledge and duration time on the eight types of landmarks for presence and absence of goods-classification. It can be seen that the measuring scores of route knowledge were the largest and the time of duration of goods-finding was shorter while the presence of goods-classification combined with landmarks in the type of alphanumeric + 2D picture + 3D object. Simultaneously, it happened in absence of goods-classification. Taken together, the findings show that goods-classification was much important in goods-finding when participants navigated in the 3D virtual store, and the landmarks could be seemed as redundant codes. If there is more information from landmarks on goods-finding in the 3D virtual store, the acquisition of route knowledge of participant would be better. Additionally, if the duration of goods-finding in 3D virtual store is short, the survey knowledge would be not easily made up and little impact on goods-finding.



Presence of goods-classification **Absence of goods-classification**

Fig. 2. Mean scores of route and survey knowledge and duration time on the eight types of landmarks for presence (left panel) and absence (right panel) of goods-classification

4 Conclusion

1. Analysis of the goods-finding task with goods-classification in the 3D virtual store indicates that classification had a significant impact on acquisition of spatial knowledge and goods-finding. When the goods are classified in different showrooms in accordance with natures, the showrooms would be regarded as a regular graphic representation of the entire geographic area, including the layout of elements (i.e. showcases) and the spatial relationships among them. Therefore, a clear cognitive map representing the environment including position and direction information would be constructed easily.
2. Landmarks are also important for goods-finding in 3D virtual store, no matter what combined type is used. The finding also reflects the more advantage of having landmarks in the 3D virtual store environment particularly when goods were classified. However, If goods-classification was absent in such an environment, one could have additional information from landmarks to process. Such information enables the determination of one' s current position and basis for goods-finding.
3. In correct goods-finding responses, we found that no mater goods are classified or not, the landmark in type of alphanumeric + 2D picture + 3D object has good effect on the acquired spatial cognition.
4. Landmarks are not the only resource to make up spatial knowledge in 3D virtual store; goods-classification also is a good one and may be more important than landmarks.

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