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Abstract

Virtual environments (VE) are increasingly used for evaluation of various product prototypes. It requires locomotion which can be either physical or virtual. This study focuses on how the way of locomotion effects on remembering the details of virtual objects. The results indicate that users' activeness is significant, no matter if locomotion is virtual or physical.

Keywords: VE Users, Virtual design, Locomotion in VE, Movement pattern

1. Introduction

Virtual environments (VE) are increasingly used for evaluation of various product prototypes. VE is useful for these situations since users can share the same view in a proper scale and in a proper environment and can communicate about virtual product prototypes. The VE users are customers and other stakeholders who typically visit, for the first time, a walk-in VE in a product test situation. VE users' own navigation improves the understanding of virtual objects [1, 2]. However, non-professional users have been observed to have great difficulties when navigating in VE [3 – 5].

In VE studies focusing on locomotion problems, the main emphasis has been on the development of new technical solutions for solving users' problems [6]. These technological solutions have mainly been devices for locomotion control by zooming and rotating the image. In terms of movement, *zooming in* means going towards virtual objects and *zooming out* moving away from them. *Rotating* the image means changing the perspective of watching the image and changing the moving direction.

Besides focusing on technical solutions, another way to study locomotion problems is to focus on users' actions [see, e.g., 1, 7, 8]. We follow this research line. Our aim is to get some basic information for designing occasional users' visits in VE, while they are evaluating virtual prototypes. One part of the VE visit is the navigation task. It needs to be decided whether the navigation task should be given to an occasional user or be taken care of by an operator. The users' own locomotion control in VE might increase the feeling of presence and thus increase the amount of information that he/she will understand during the visit in VE. On the other hand, there is a risk that the user concentrates on the navigation task, rather than on watching and evaluating the virtual prototype to be evaluated.

In our study of occasional users' actions in VE we have four objectives. *Objective 1* is to identify how occasional users control locomotion in VE. Early studies focus on the use of technological devices [e.g., 1, 9, 10], and the users' own body [e.g., 11]. We study locomotion control from a different perspective: that is, how users act in VE to see the virtual objects which exist there. We assume that there are differences among VE users, since it is known that they use different strategies in the navigation task [9]. We study locomotion control with the concept of pattern, which means "a guide or set of instructions for making something" [12]. In our case, pattern refers to a set of (physical and virtual) movements which a visitor employs in VE.

Objective 2 is to analyze whether there is some relationship between occasional users' way of moving and remembering virtual objects. Early studies indicate that active users of technology remember information better than passive users do. Similar results have been obtained with the use of VE technology [1, 2] and the Internet [13]. In earlier studies, researchers have divided the test users into passive and active groups. We let the test users themselves decide how they move, which movement pattern they use and how active they are in its use. We are interested in whether there is relationship between their movements and remembering.

Objective 3 focuses on users' own evaluation of the easiness of technological locomotion control; i.e., whether those who found it easy to use a technical device, used it actively and remembered the details of virtual objects well. This objective is based on Technology Acceptance Model (TAM), which states that people use technology when they find it useful and easy to use; TAM characterizes items with their "perceived ease of use" and "perceived usefulness" [14, 15].

Objective 4 is to find out what kinds of users belong to each movement category. We focus on their demographical features, as early studies state that there is a connection between users' actions in VE and their age [e.g., 8, 16] and gender [e.g., 17, 18]. In our case, in which VE is used for product development, planning occasional users' VE visits and product presentations would be easier if we could forecast how a person will act in VE.

We studied the above objectives by organizing a user test in VE. In our case, VE refers to an immersive walk-in virtual reality environment in an artificial, visual, three-dimensional world that is completely generated by a computer. We organized a user test in which 40 test users visited a small shopping centre. In the first room the test users walked, in the second one they were navigated by an operator and in the last room they navigated by themselves. After the VE visit the test users did a memory test about virtual objects. The environment of the test and the test users are described in detail in the next section.

In the section following that we present the results of our test use. We categorised the test users to four movement categories. The results show that the activeness in moving is related to success in the memory test. However, activeness in controlling the movements with technology and physical activeness – that is taking steps – have the same effect. Finally, at the end of the paper there is a discussion, which outlines the outcomes to the objectives and considers their meanings.

2. Experiment

We studied the objectives by conducting a laboratory test in VE with 40 test users from different backgrounds. The test included both a guided tour in a VE and the test users' own navigation task. Next we describe the methodological issues in more detail.

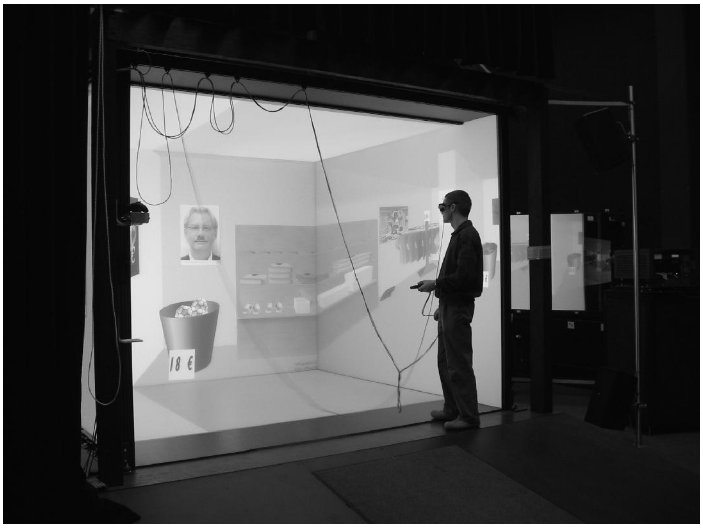


Figure 1. The virtual environment and a part of the model

Figure 2. The Wanda input device

2.1. Test environment

The Cave-like VE used in this study has five rear projection surfaces: three walls, a floor and a ceiling (see Figure 1). The dimensions of the space are 3.0 m * 3.0 m with height of 2.4 meters. The display resolution is 1280 x 1024 pixels per wall producing a view consisting of up to 6.55 million pixels. The users' view is rendered according to his/her position and orientation using a magnetic tracking system. An active stereo image is observed through liquid crystal glasses with a frequency of 2 x 45 Hz. For controlling movements, we used an ordinary Wanda input device that has one button for speed (on/off) (Figure 2). The speed was set up to that of a normal walking speed. A direction of movement can be chosen simply by targeting the direction.

We created a model of a small shopping centre for this test (Figure 3). The model was authored with 3DstudioMax software and visualized with VR4Max application running on Windows XP. The model includes three small rooms and a lobby. The rooms are:

Room 1: A product presentation room which includes a table with product models placed on it.
Room 2: A sports shop which includes sportsware and balls, and posters on the walls.
Room 3: A cloth shop which includes cloths, posters and two human-size dolls.

The VE in which the test users walk and navigate is small and narrow. The dimensions of the sports shop are 4.3 m * 4.0 m and the cloth shop 4.0 m * 3.0 m. The cave is only a bit smaller (3.0 m * 3.0 m). Both of the shops include a partition wall, which makes navigation more difficult. Simple collision detection is used, so it is not possible to walk through the walls. However, collision detection is not used with items in the shops so it is possible to walk through a clothes rack, for example.

The test situation is presented in Figures 1 and 3. Figure 1 illustrates the view from the door of the sports shop. Furthermore, it shows the physical environment with the real walls and tools, i.e., Wanda, glasses, and cables. Figure 3 includes a perspective picture of the shop premises; the lobby and the three rooms.

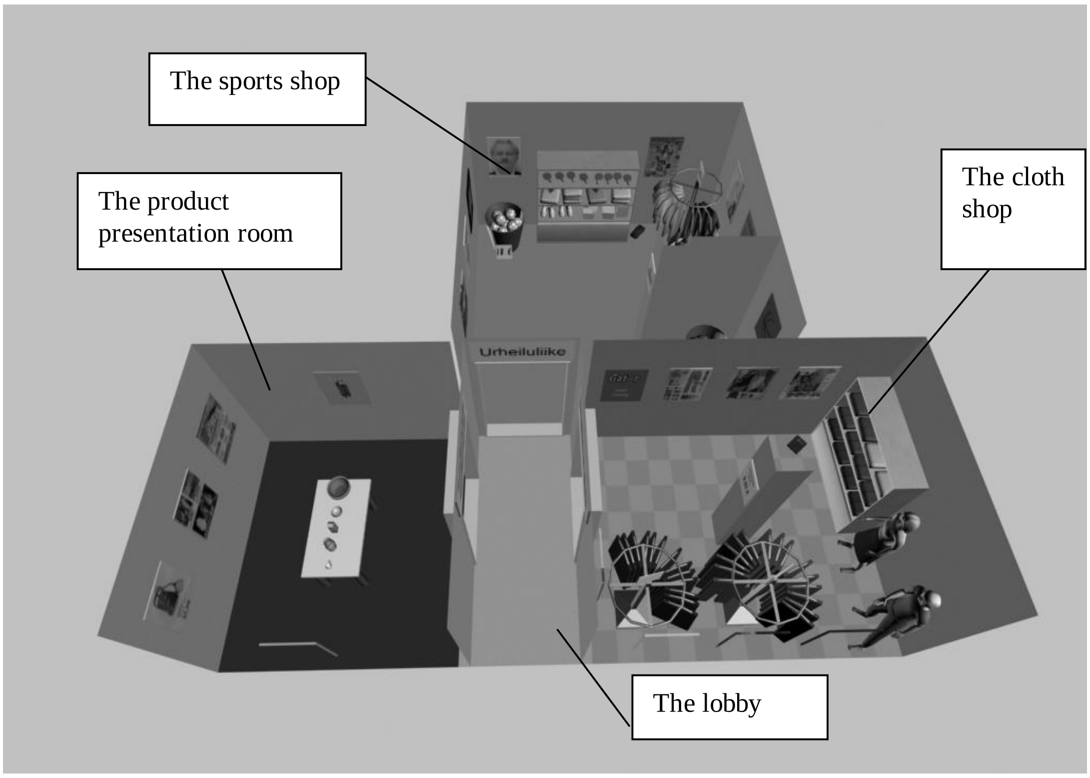


Figure 3. The model of the small shopping centre used in the test

2.2. Test users

For the user test we had a group of 40 test users. Such a high number of subjects is rare in VE user studies, since each individual VE test takes a long time. The test users need to be taken through the test separately, they need some guiding there and some practice as well.

VE tests often use students as test users [see, e.g. 19, 20], so we also decided to have one half of our test group IT students whereas the other half consisted of consumers of different ages. Volunteers were sought by sending a request to several e-mail lists such as a local academic information list (which includes business people and communal actors). The common attribute of all test users was that they were familiar with ICT; they had to read e-mail to get the request and fill in an Internet form to show their willingness to participate in the test. The other common attribute requested was that they had not visited a Cave-like VE before.

We conducted the test with 40 users in the spring of 2007. The average age of the test users were 36 years. There were more males than females among them – 26 men and 14 women. More detailed demographical information is presented in Table 1.

Table 1. The demographical information of the test users

Participants	Students		Consumers		Total
	Male	Female	Male	Female	
Between 18 – 25	10	2	0	0	**12**
Between 26 – 39	4	3	5	4	**16**
40 and over	1	0	6	5	**12**
Total	**15**	**5**	**11**	**9**	**40**

2.3. Test process

Three members of the research group participated in the actual user tests. There was an operator who was responsible for the VE equipment, a research assistant who guided the test users and a researcher who observed the test users' behaviour and interviewed them. Before the test users' visits to the VE, the three research group members practiced the test procedure and performed two pilot tests.

For the test process, ethical research issues had been considered; for example, anonymity and gaining consent for videotaping [e.g. 21]. The test users were taken individually to the test situation. After a short, theoretical introduction for using the Cave-like VE, the test user was guided into the VE. At first, the users went to Room 1 in which product models were presented. The operator took the test user into the small room in which the user could take some steps to change position. After a visit lasting some minutes the operator navigated the user to the first shop. The test user was asked to think aloud and see whether there would be something interesting available. All test users were guided in the first shop, a sports shop or a cloth shop, which was chosen randomly.

Before going to the second shop, the test user got practical advice on using the Wanda device to navigate in the VE. The research assistant followed the test user into the shop, encouraged him/her to check out all around the shop and helped in any problems. The test users had three minutes for moving by themselves. We decided to allocate only three minutes for each of the shops because the shops resembled traditional shops; based on the pilot tests, the time was sufficient to see all the items available in these kinds of shops.

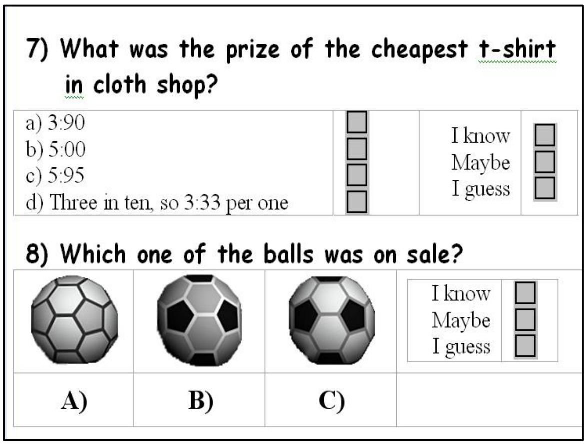
2.4. Fill-in Form - Memory test and Evaluation of use

After the VE visit, the test users completed a memory test. Both in the real world and in a virtual environment, people recall, remember and understand better information which is presented in a consistent environment [22]. Therefore, the test environment was a shop, and the items were things that belong to such shop. Also, the questions in the memory test focused on things that could be asked about in a shop, such as the prize of a shirt, whether there were certain items in the shop and, if so, something about their features. The questions were designed to be easy, and so we expected a high number of correct answers.

The test included nine questions: five of them dealt with the sports shop, three with the cloth shop and one compared the two. Some of the questions included pictures (one of them was a product in the shop) and some were verbal (about the colours or prices or number of products in the shop). With the help of choice alternatives "I know", "Maybe", and "I guess" it was also determined how sure the test user was. Figure 4 presents two examples of questions in the memory test. The questions were originally in Finnish since all the test users were native Finnish speakers.

After the memory test, a question about the easiness of the locomotion control was put to the test users. We had formulated statements based on our knowledge about possible alternative impressions on VE visits. The test users were asked whether they agreed or disagreed with the statements using an evaluation scale of five units (totally agree, partly agree, cannot say, partly disagree, totally disagree). The order of the statements was mixed, whether positive or negative, so that the test user had to think about the answer for each of them – choosing one answer for all would not have worked. The statements were:

1. When the guide navigated for me, it gave me an excellent opportunity to look at the products.
2. It was easy to learn how to use Wanda for locomotion.
3. When I used Wanda, I could concentrate on the products I was interested in.
4. When I controlled locomotion, I found the VE space more realistic as a shop.
5. The guide showed me just the products that I wanted to see.
6. I did not get enough training in locomotion control.
7. I found locomotion control easy.
8. When I was controlling locomotion, it was sometimes hard to get to the direction I wanted.


7) What was the prize of the cheapest t-shirt in cloth shop?

a) 3:90
b) 5:00
c) 5:95
d) Three in ten, so 3:33 per one

I know
Maybe
I guess

8) Which one of the balls was on sale?

A) B) C)

I know
Maybe
I guess

Figure 4. Two examples of the questions in the memory test

2.5. Analysis

During the test use we collected several kinds of data. The first data set includes test users' background information, such as age and sex. This was collected before the test. The second data set consists of the forms containing users' answers to the memory test and the evaluation of pleasure experienced by the users during the VE visit. Each user had filled a form after the VE visit. The third data set consists of videotapes of test users' visit in the VE.

There were 40 test users who participated in the test. Four test users were discarded from the analysis due to technical problems in VE or in videotaping. Those test users were all men, two of them belonging to the youngest group and two to the oldest (see the categories of Table 1).

The data sets were first analysed separately and then in combination. Using the videotapes, we analysed how the test users moved in VE. For each test user we calculated the number of steps taken and the usage of Wanda. Wanda was mostly used for zooming in and out, but there were a few rotation changing operations executed with Wanda as well. Otherwise, the test users used Wanda in various ways. Some of them zoomed continuously to arrive in a desired place, some zoomed repeatedly in tiny increments until they reached their destination. The number of zoomings was much higher with the latter type of users. Nevertheless, all those who actively used Wanda for locomotion ended up with a greater amount of Wanda use.

Using the forms (the second data set) we analysed the test users' success in the memory test and their own evaluation of the easiness of using Wanda. We defined the number of remembered things in the memory test for each test user from the correct answers in the memory test. As the memory test included nine questions, the value could vary from 0 to 9. Thus:

Remembering = Number of correct answers in the memory test.

The test users' evaluation of the easiness of using Wanda was also calculated. It was calculated from answers on three of the eight statements – the statements number 2, 7 and 8. The calculating expression used was:

Easiness = Answer to statement 2 + answer to statement 7 – answer to statement 8.

The answers were given a value from 0 to 5, so that total disagreement corresponded to number 0 and total agreement to number 5. When Easiness is calculated using the above expression, the value could vary from -5 to 10.

The test users' background information includes their age and sex. These were used in the analysis if there were some connection between the users' demographical features and their actions (moving and remembering) in the VE.

3. Results

Here we present the results based on the four objectives of this study. Objective 1 focuses on the ways of controlling locomotion. Objective 2 connects the controlling ways and remembering virtual objects. Objective 3 connects users' own evaluation of ease of moving with their actual movements in VE. Objective 4 focuses on the differences between the members of the categories. Next we deal with these objectives individually.

3.1. Movement patterns and categories

Objective 1 of this study focuses on how the test users control locomotion in the VE. We identified two ways of controlling locomotion: virtual and physical actions. Virtual moving means the use of technical device (Wanda) for locomotion control. With Wanda it was possible to approach and draw objects away by zooming the image and to change the point of view by rotating the image. These actions are referred to as *Virtual movement pattern*, since they consist of a set of actions for moving in a VE. Besides virtual movements, the test users moved also physically. We refer to the latter as *Physical movement pattern*, meaning the use of body activities for locomotion control. In practice this means taking steps towards and away from the objects and changing the viewing perspective.

A VE user can use one of the movement patterns, a combination of both of them, or neither of them. So there are four possible categories of using movement patterns. These are presented in Table 2.

We categorised the test users to the four categories based on the answers given to the other objectives of this study; how much each used virtual and physical movement patterns was determined by their actions during the test situation.

A test user was categorized as using a movement pattern if she/he used it more than the average in the test. However, we focused on those test users who were located just on the no-man's-land between using and nonusing. They could be moved to another category if their actions differed from those of others in their original category. Finally, we identified 21 users and 15 non-users of the physical movement pattern, as well as, 23 users and 13 non-users of the virtual movement pattern.

Table 2. Categories of using of movement patterns

Use of movement patterns	Not using physical pattern	Using physical pattern
Using virtual pattern	TECHNO USERS use virtual pattern.	WALK AND TECHNO ones use both patterns.
Not using virtual pattern	PASSIVES use no pattern.	WALKERS use physical pattern.

Table 3 presents a brief summary of the members of each category. It includes both demographical features (age and sex) and the use of both movement patterns. As there is a lot of variation among the members, we do not just present the average number of members belonging to each category but also the lowest (min) and the highest (max) numbers.

Table 3. Information about the members of the categories

	Passives	Walkers	Walk and techno	Techno Users
Members in the category	7	6	9	14
Sex: female + male	4 + 3	3 + 3	2 + 7	5 + 9
User type: student + consumer	5 + 2	1 + 5	4 + 5	7 + 7
Average age	36	46	34	34
Age: min – max	23 – 63	25 – 66	21 – 51	22 – 72
Use of virtual movement pattern: min – max	5 – 21	1 – 18	21 – 54	23 – 93
Use of physical movement pattern: min-max	0 – 7	13 – 20	10 – 35	0 – 7
Average number of right answers	4,3	6,0	6,1	6,1

3.2. Remembering Virtual Objects and Moving Categories

Objective 2 focuses on the possible relationship between moving in VE and remembering the virtual objects. A general picture emerges where active VE users are the best in remembering virtual objects as shown in the results in memory test by moving categories in Figure 5. However, there is quite a lot variation within each category. The members of the *Passives* category do not move actively in the VE, and their success in the memory test is lower than the active VE users. The members of the three active categories – *Walkers*, *Techno users*, *Walk and techno* – succeed well in memory test. The average number of correct answers is 6, whereas *Passives'* average number is 4,3. Nevertheless, also the categories of active movers include some members, whose succeed in memory test is not so well, as presented in Figure 5.

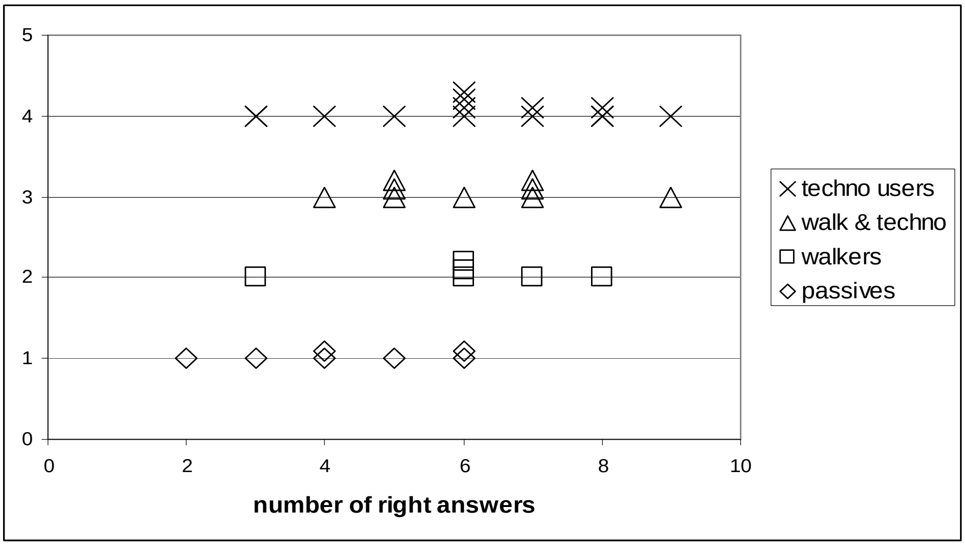


Figure 5. The number of remembered objects by the categories in the memory test.

3.3. Evaluation of Easiness and Actual Moving

Objective 3 focuses on whether the VE users' own evaluation of the easiness of using the locomotion control device is connected to its actual use (see, Figure 6). All categories include members who evaluated the use of Wanda easy. Also some of *Walkers* and some of *Passives* evaluated it easy, although they had been using it only few times. On the other hand, all the moving categories include members who evaluated the use of Wanda hard. This applies also to *Techno users* and *Walk and techno*, who used Wanda actively. So the results of our study do not support the assumption that VE users' own evaluation of the easiness of using Wanda is correlating to its actual use.

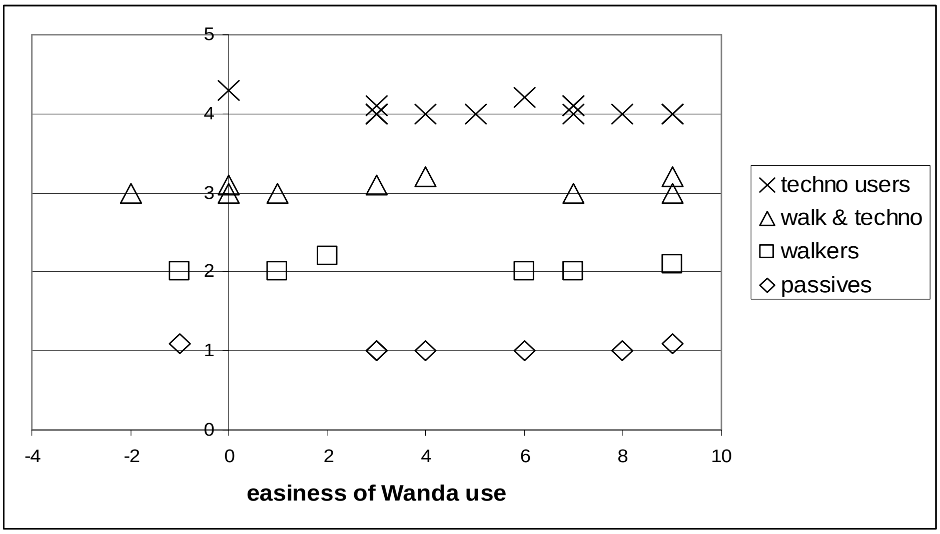


Figure 6. The test users' own evaluations of the easiness of Wanda use presented by the categories

3.4. Who belong to each moving category?

Objective 4 focuses on what kinds of people belong to each category. Table 3 shows that there is no gender difference among the categories. It also shows that the average age of the members of *Walkers* is higher than in other categories. This difference, which we will analyse next, may be connected with the type of users. The resulting statistics are presented in Table 4.

Table 4. Comparing student and consumer test users of each category

		Passives		**Walkers**		**Walk and techno**		**Techno Users**	
		student	consumer	**student**	consumer	**student**	consumer	**student**	consumer
Number of members		**5**	2	**1**	5	**4**	5	**7**	7
Age	min - max	**23 – 34**	49 – 63	**25**	35 – 66	**22 - 30**	26 - 59	**22 - 29**	24 - 72
	average	**27,8**	56,0	**25,0**	50,2	**24,5**	41,4	**26,1**	41,3
Use of virtual pattern	min - max	**5 – 21**	8 – 21	**18**	1 – 18	**22 - 54**	21 - 35	**23 - 93**	25 - 58
	ave	**13,0**	15,0	**18,0**	11,8	**37,0**	28,0	**52,3**	37,3
Use of physical pattern	min - max	**0 – 7**	4 – 5	**13**	13 – 20	**12 - 20**	10 - 35	**0 - 7**	2 – 7
	ave	**2,2**	4,5	**13,0**	16,6	**14,8**	17,2	**2,1**	4,7
Objects remembered in the memory test	min - max	**2 – 6**	3 – 6	**6**	3 – 8	**5 - 9**	4 – 7	**6 - 8**	3 – 8
	ave	**4,2**	4,5	**6,0**	6,0	**6,5**	5,8	**7,3**	5,0
Easiness of Wanda using	min - max	**3 – 8**	-1 – 3	**6**	-1 – 9	**0 – 9**	-2 – 7	**3 – 9**	0 – 7
	ave	**6,0**	1,0	**6,0**	3,6	**4,8**	2,4	**6,7**	3,9

Our test included two kinds of test users: students and consumers. The distribution of test users of the two groups among the moving categories differs. Most of the members in the category of *Passives* are students whereas only one member of *Walkers* is a student, as shown in Table 4. Both of these observations are explained by the student test users' avoidance of the use of the physical movement pattern: Six of the twenty student test users did not use the physical movement pattern at all.

Although all moving categories include students, we can identify some features which are typical in students' behaviour in VE. First, they avoid physical movements. This means that they either control locomotion with a technical device or are passive in VE. Second, passive students' success in the memory test is poor, but the success of others in it is good. Third, they find the use of Wanda easier than do the consumers of the same moving category.

Besides the differences between students and other people, one needs to focus on whether older test users differ from the others. Our analysis shows that there are no differences: All the moving categories include also old test users (as shown in Figure 7), and the old test users act the way the others do.

The actions of the oldest are attributed to the oldest member of each category who does not differ from the other old category members. In the category of *Passive*s the oldest person was a 63 year-old woman. She was pretty close to being an average member of the category by the result of memory test and the evaluation of Wanda use. In the category of *Walkers* the oldest person was a 66 year-old woman, just about an average in the category. In the category of *Walk and techno*, the oldest person was a 59 year-old woman. Her result in the memory test was over the average of the category. She used Wanda an average number of times, although she found using it harder than on average. In the category of *Techno users* the oldest person encountered was a 72 year-old man. When comparing his results to those of an average user of the category, it is found that the number of times Wanda was used is the same, the number of steps employed is higher, the use of Wanda is evaluated harder and the result of the memory test is a bit poorer. The person in question cannot be regarded as being extreme in any of the features, however his use of the Physical movement pattern was valued seven, which is the highest number among *Techno users*. Nevertheless, there were also three others in other categories who took seven steps.

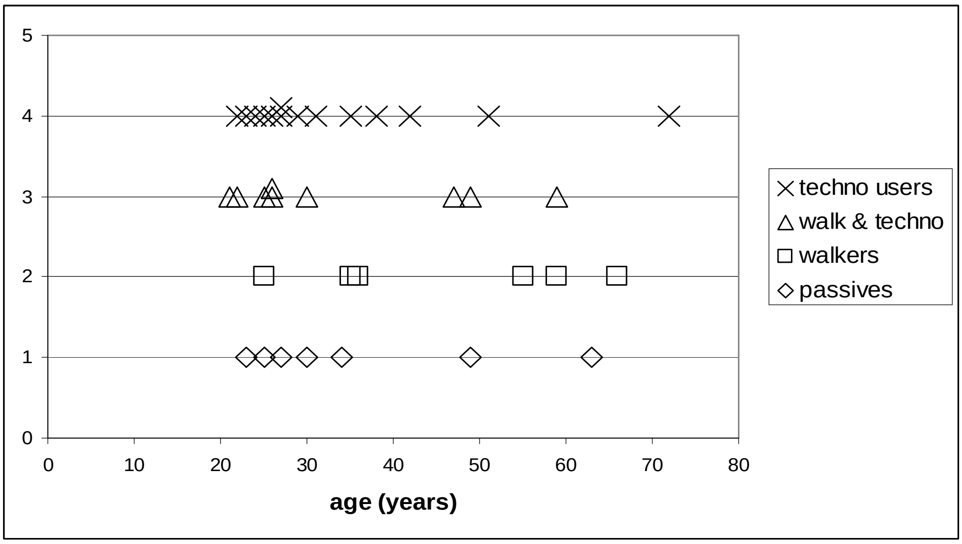


Figure 7. Age of the members of each category

3.5. Summary of Moving Categories

We created four moving categories based on two movement patterns – a virtual and a physical one. Here we summarize the categories and outline their members.

The category of *Passives* includes 7 members. They are called passives, because the number of activities they undertook is lower than the number of activities engaged in by the members of other categories. They did not find using Wanda more difficult than did the members of other categories. The *Passives* members did poorly in the memory test on average. The category includes two test users, a young man and an older woman, who used virtual movement patterns more than others did. They differ from the others in the category of passives, since they remembered more in the memory test. They were quite similar to those members of *Techno users* who used Wanda the least.

The categorization is needed for making the VE situation understandable. Occasional users' VE visit is a complex situation which includes several features (such as users' demographical attributes, their movements in VE, remembering virtual objects and their own evaluation of the easiness of certain tasks). With categorization, it is possible to characterise different user types, based not on their demographical attributes but on their behaviour in VE.

The category of *Walkers* includes VE users who (almost) exclusively use the Physical movement pattern. There were 6 test users who belonged to this category; three men and three women. Their average age was 46, so they were much older than the members of the other categories. All *Walkers* tried to use Wanda. One tried it only once; she was a 35 year-old woman. She did well in the memory test and found using Wanda easy.

Those test users who (almost) without exception use the virtual movement patterns belong to the category of *Techno users*. On average they found using Wanda easier than did other categories, however, there were lots of variations in how easy it was found using Wanda. Among our test users, *Techno users* is the biggest group: 14 test users belong to this category. The number of students and consumers as well as also older test users belonging to *Techno users* was equal.

The members of the *Walk and techno* category used both the virtual and physical movement pattern. Of the test users, 9 were in this category. They differed from the other categories by the members' evaluation of the easiness of Wanda use: they found its use harder than did the members of other categories; however the variation among this category was large.

5. Discussion

We studied occasional users' ways of moving in VE with a user test. The test users visited a small virtual shopping centre and did a memory test afterwards. In this research setting we focused on four objectives, and here in this section we present the findings from the study of each objective.

Objective 1 of this study was to identify how occasional users control locomotion in VE. This was done by identifying two movement patterns. The physical movement pattern focuses on movements of the body, such as taking steps, whereas the virtual movement pattern indicates that locomotion is controlled with a technical device, such as Wanda. Furthermore, VE users did not choose one or another movement pattern, they made practical choices with the movement patterns independently: a VE user could use one of the two movement patterns, both of them, or neither of them. Based on the use of movement patterns, we defined four moving categories:

1. Passives who use neither of the patterns
2. Walkers who use the physical pattern
3. Techno users who use the virtual pattern
4. Walk and techno ones who use both of the patterns.

Objective 2 was to analyze the relationship between occasional users' movements and remembering virtual objects. In our test the active users recalled more objects in the memory test than the passive users did. Not only the use of the virtual movement pattern but also the use of the physical pattern had a positive impact on the memory test. In all groups of active movers – *Walkers, Techno users*, and *Walk and techno* – there were at least some users who did well in the memory test. Only the *Passives* group did not include anyone who would have done well in the memory test. Our result, which indicates that active users do better in the memory test, is in line with earlier studies on understanding information through technology [1, 2, 13, 23] and with studies on active learning [24].

Objective 3 focused on users' own evaluation of the easiness of technological locomotion control. The hypostasis was that those who found using Wanda easy, used it actively and did well in the memory test. Connecting users' own evaluation of easiness with their actual use of Wanda was based on the technology acceptance model (TAM) which states that perceived usefulness and perceived ease of use explain the use of technology [14]. However, our study does not provide any support for this, as we found no correlation between the users' evaluation of the easiness and their actual use of Wanda. Furthermore, all moving categories included both test users who found using Wanda difficult and those who found it easy. Some other studies have come up with cases where TAM cannot explain the (non-)use of technology [e.g., 15].

Objective 4 was to find out what kinds of users belong to each action type (a certain type of moving and remembering). We focused on the demographical features of users, as early studies state that there is a connection between users' actions in VE and their age or gender. We did identify some age differences but there were no gender differences among our test users. One age difference we found among the young test users (the student test user group in our case) was that they avoided using only the physical movement pattern. This was indicated by the overrepresentation of student test users in the category of *Passives* and their scarcity in *Walkers*. This finding is, to some extent, in line with stereotypical thinking about technology use [25], which associates technology with young people. On the other hand, stereotypical thinking asserts that old people avoid using technology. However, our test use does not support the latter assumption, since the old users in the test used technological locomotion controlling device actively and their memory test results were on the average level. Our results thus go against the findings of older VE studies [e.g., 8, 16].

Our finding about students' different VE behaviour – their avoidance of Physical movement pattern – is remarkable from the research methodological point of view. The use of students as test users is very common in VE studies [e.g., used in 19, 20], as well as in other technology related studies (see, a review [26]) as students are easy to recruit. However, if students act somewhat differently with technology and with VE, it is important to outline the possible limits when students are used as test users in VE studies.

The practical aim of our study was to get some guidelines for organizing occasional users' VE visits. The results of our study suggest that VE visits for these kinds of visitors should be designed so that the they could use both the virtual as well as the physical movement pattern, as some actions can be performed in both ways – i.e., by taking physical steps and with a technical device – and let them choose which one to use.

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