The influence of viewpoint correction to virtual human agents interacting with humans through pointing tasks.

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ABSTRACT

This paper researched the influence of adding viewpoint correction to virtual human agents. A new combination of measurement tools was introduced that used head tracking software and virtual human agent software. This research looked from the human perception using an experiment with a questionnaire to indicate statistical reliable differences. There was one group of test subjects with viewpoint correction and one group of test subjects without viewpoint correction. The influence was measured on realism and presence. In the experiment the virtual human agent performed pointing gestures while giving the test subjects tasks.

Keywords

Wii-mote, Elckerlyc, virtual human, viewpoint correction, head tracking, human machine interaction, pointing task, influence, realism, presence, questionnaire

1. INTRODUCTION

Virtual human agents can be used in many ways. Changing small parameters to virtual human agents may result in certain changes that are important in the use of virtual human agents. The parameter that draws the attention for further research is viewpoint correction. A paper [6] about hacking the Wii-mote shows an interesting use of adding viewpoint correction. Combining this parameter with virtual agents has not been done before and gives the opportunity for more interesting research. When combining such a parameter with virtual human agents, realism and presence might be influenced.

To see a difference in influence a 2D virtual human agent with and without the addition of viewpoint correction is required. Viewpoint correction can be used in different situations with a virtual human agent. The approach of this paper was to let the virtual human agent point and tell a human to interact with it. The virtual human agent asked two simple tasks. The first task is to pick an object up and the second task is to put an object down. This interaction expects certain influences which is caused by adding viewpoint correction.

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Are humans, from their own perception, influenced by adding viewpoint correction to a 2D virtual human agent that uses pointing gestures when giving tasks to a human?

- What are the variables that are important to question when surveying a test subject?
- What are the current questionnaires about these variables? And how can these questionnaires be combined and adjusted to the relevance of the research?
- What influence from the environment can have an effect on the results of these variables?
- What can be concluded from the raw results of the questionnaires?

The research questions were answered by studying literature and a laboratory study in which humans interact with a virtual human. This laboratory study required a certain experiment setup, so some sub-questions might arise on how the measurement tools were made, because these tools did not exist yet. In this case viewpoint correction had to be added to an existing 2D virtual human agent.

An important part of the answer to the research question is the proper way to know what the discussed influence is. The differences in realism and presence in the experiment with and without head tracking were retrieved from a test subject using a questionnaire. The first research question found the right variables through literature study. The second research question was answered through a clear view on the experiment and a literature study. Information about the environment in the experiment that influenced the test subject was required, because this give more valuable conclusions. This was done in the third research question. In this question only the relevant environment changes about realism and presence were discussed.

For this research a virtual human agent has been programmed for giving the test subjects tasks while pointing at some object. The experiment was one group with and one group without the addition of viewpoint correction. The addition of viewpoint correction was done by combining software with the virtual human agent software. This combination was not made before so the system specification will require some discussion.

The system specification and experiment for this research was made in combination with another research [1] that required the same measurement tools, though that research focused on the performance effects instead of the perception of human, where our research will have its focus upon.

The results of the experiment gave data from the questionnaires that helped answering the last question and finally the main research question. The last question was answered using software for statistical analysis. Differences were detected using a t test.

First a foundation must be laid based upon earlier research in chapter 2 about related work. In chapter 3 the measurement will be discussed. To show how this research went the first thing to discuss is the system setup that was built for this research. After that a description of the experiment will be given. In chapter 4 the raw results will be displayed using statistical analytic software. These results will be discussed in chapter 5. At the end in chapter 6, with all the gained knowledge, conclusions will be drawn.

2. RELATED WORK

There are certain important variables to human and to future research based upon earlier research [3]. In this research a study is done on the influence of realistic virtual human representations and increased realism that occurs. Study 2 examined behavioral realism and agency believes. The research showed that virtual humans that were high in behavioral realism are more influential than the virtual humans that were low in behavioral realism. Study 2 of this research confirms the idea that realism might get influenced when adding viewpoint correction, if realism is increased. Realism and presence will be used as variables to find the right constructs for the questionnaires [4],[5]. These two papers developed a measure for social presence. [5] is about an acceptance measure at first, but one construct is about social presence and questionnaires related to social presence. A few of these questionnaires also refer to realism. So these two papers can be used to create a questionnaire using validated questionnaires. Chapter 3 will discuss this is more detail.

A research with the Wii-mote for head tracking [6] shows that viewpoint correction can be added. This study shows the I/O capabilities of the Wii-mote support a lot of potential applications. For our experiment the Wii-mote can be used for head tracking purposes using infrared LED's (see figure 5 in [6]). Elckerlyc [7],[8] can be used as an virtual human agent framework. [7] and [8] show what Elckerlyc is. Important was that Elckerlyc could be modified easily, which is one of main characteristics of Elckerlyc. Elckerlyc is a BML realizer, which was required for the experiment with pointing tasks. BML (Behavior Markup Language) is a language to control the virtual human agent. How the Wii-mote with head tracking and Elckerlyc were combined will also be discussed in chapter 3.

3. MEASUREMENT

3.1 System setup

3.1.1 Overview

Connecting head tracking with a virtual human agent software was necessary, because this allowed test subjects to interact with the virtual human when wearing a head tracking device. The virtual human gave tasks to a test subject when pointing at an object. This also required a grid where the objects in real life were placed. The data of the Wii-mote is used to change the position of the camera relative to the virtual human. Elckerlyc [7],[8] is the virtual human agent framework that was used. It was required to adjust some parts of Elckerlyc to get the right camera position in space. Then Elckerlyc had certain output that needed to be sent towards the display of the user.

3.1.2 Connecting Elckerlyc and the Wii-mote

For this type of research there was no system that connected head tracking with virtual human agents. To build such a system we needed a head tracking device so that the position of a test subject could be determined. The head tracking device should receive some coordinates which then should be connected to the camera within the virtual human environment. The Wii-mote with infrared LED's can be used as such a head tracking device. When using the Wii-mote and the right software it was possible to receive coordinates and pass them on to the virtual human environment, which is Elckerlyc. The most important change consists of connecting these two and make them work as one system. It was also required to translate the coordinates from the Wii-mote into a camera position in Elckerlyc, which will be discussed later on in more detail. Both the Wii-mote head tracking code and Elckerlyc were written in Java, so code that connects these two was also written in Java.

3.1.3 Client-server model

In this case a distributed system was built so one desktop computer would run the Wii-mote head tracking code, which was the client side, and one desktop computer would run the Elckerlyc software, which was the server side. The client side had the ability to connect with the Wii-mote using Bluetooth. Because of the closed source of the communication between Bluetooth and the Wii-mote there was barely information on error handling. So the startup and disconnection of the system required some strict rules, while giving unknown errors sometimes. Though when the system was running it was stable. The client sent coordinates to the system. The client also controlled the BML for the specific written scenarios. These scenarios will be discussed in the next section about the experiment setup. The server received the coordinates and translated it to a camera position. The server also listened to the client for BML and then executed it on the virtual human. In Elckerlyc the camera worked with a VJoint, which is a virtual point in the room that can be manipulated. To manipulate the camera we needed to adjust the VJoint of the camera.

3.1.4 Calibration of head tracking

First the calibration of the head tracking required a translation of the coordinates to a VJoint position. We were able to find something that was able to calculate the two coordinates of the infrared LED's into (x,y,z) coordinates and a camera rotation. The camera rotation and the (x,y,z) coordinates were used for the VJoint position. This calculation had to be calibrated so that it looked realistic. Important was the use of real life objects to see how it changes when moving your head around it. By doing this the change of the rotation and position could be calibrated to the real world. Because when moving your head around objects as well as the rotation of the camera as the position in space changes. The hand of the virtual human was pointing to the screen as close as we could, because this would be a good reference point to start with. The hand at that position should not be able to change in (x,y,z) coordinates to the human perception when moving your head, but only in rotation of the camera, when calibrating on this point. This was done, because depth is not able to be perceived on a 2D monitor. So the position of the hand should be determined on a position of which we are certain that the hand cannot be perceived on a different location due to no depth. The best position was as close to the screen as possible, because this depth can be seen in real life with human perception.

3.1.5 *Calibration of the grid*

There was also a grid required in order to let the virtual human point at certain objects. So an empty A0 paper was used as a grid. On the border of the grid on the A0 paper there were strokes that indicate the position of the gridlines (see figure 1). Another task was to connect the grid with the virtual grid. The virtual grid consisted of VJoints that could be used by the virtual human to point at in BML. To decrease the amount of gridposition that need to be calibrated the four positions of the vertices of the grid could be used in order to calibrate the grid with the virtual grid. First we needed to calibrate the four positions of the vertices. To do this an object was placed in real life on one of the vertices on the grid, then the virtual human would point to the vertex and the positions was recorded. The same procedure followed for the other three vertices. After that the rest of the grid needed to be calculated using some mathematics. Only three vertices (bottom-left, bottom-right and upper-left) are needed to calculate the whole grid, the fourth one (upper-right) was used to check the reliability of the calculation. First the length between bottom left and the two other vertices were calculated. To calculate the next gridpositions one used the bottom left (x,y,z) coordinates add an amount using the length divided by the gridposition of the other two vertices. At the end the last gridposition was subtracted from the upper right vertex which gave a nice result which was very close to zero. This meant that the calculation was done well and that the four vertex calibration was done accurate.

Figure 1. Indication marks for the gridlines.

3.2 Experiment setup

3.2.1 *The environment*

The experiment was done in a closed room inside a laboratory. The entire setups was done using two desktop computers. This was necessary, because the desktop that was used to get head tracking working was fully set up to run the Bluetooth connection with the Wii-mote. This desktop was actually too slow to run both the head tracking software and the Elckerlyc software, so we decided to distribute this. Opening a simple network connection between the desktops using a client-server model was the best option, for it would take more effort to run head tracking on a different desktop. The client would then run the head tracking software and the client would sent BML to the server. The BML that was sent corresponded to two scenario's. The two scenario's had different scene's. Every scene described a task for the test subject. Every scene had a different button in the GUI of the client. There was a table with a monitor on it (see figure 2). In front of the monitor there was another table with the A0 paper on it. For every scenario there were different type of objects that would be placed on this A0 paper. Only on the edges of the A0 paper there were marks so the objects could be placed in the right positions. In front of this table was a chair were the test subject was able to take a seat. The Wii-mote was positioned under the monitor. The head tracking infrared LED's were built into a wearable device. A photo camera was positioned above the grid using a hanging tripod. The photo camera would take pictures for analysis. Another laptop was placed somewhere else in the room. On this laptop there was a questionnaire that was filled at the end of every experiment. The questionnaire would gather data for analysis, which will be discussed in the next chapter. It was possible to perform more experiments processes at once, because someone was able to do the part of the experiment with the virtual human agent and one was able to fill the questionnaire.

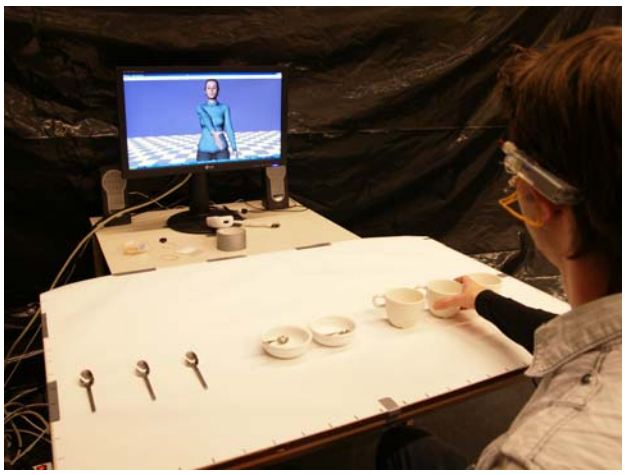

Figure 2. Technical experiment setup

3.2.2 *Scenarios*

There were two scenario's. The first scenario was with three object sets as displayed (see figure 3). In this scenario three coffee mugs, three teaspoons, sugar and milk was used. In the second scenario the test subject dealt with three beers, three beer glasses and two beer openers as displayed (see figure 4). In the first scenario the objects were placed in horizontal order. In the second scenario the objects were placed in vertical order. The main difference was that objects in vertical order might be harder to see due to depth. In the scenarios the test subject were asked to place the objects somewhere on the table in front of the agent. The basic idea was to pick up objects from the table and place them somewhere on the table.

In the whole experiment everything should stay as constant as possible. Every experiment followed exactly the same procedure as described above. Every scenario was the same for every test subject. It was also important that the test subject were not aware of the data that was about to be analyzed. The grid did not have any lines on them to make sure that test subjects were not aware of what was analyzed. Only on the edge of the paper there were some lines that were used to positioning the objects and for the analysis of the photo's. When the questionnaire was about to be filled a simple instruction about the values on the Likert scale was given to each of the test subjects. This prevented misinterpretation of the Likert scale values.

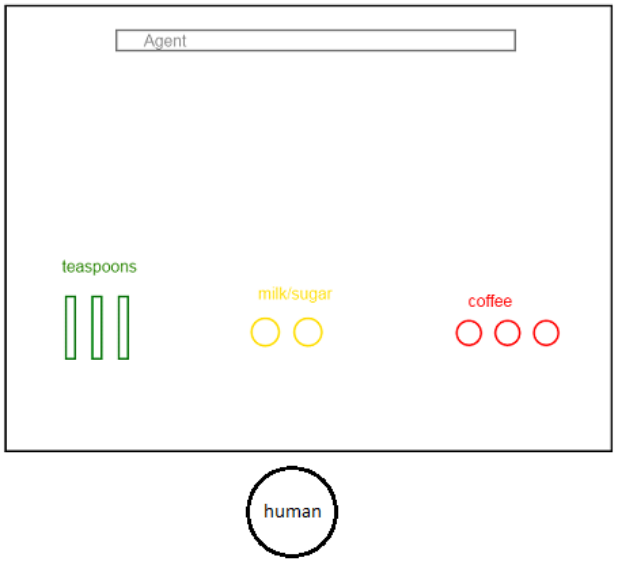

Figure 3. Scenario 1

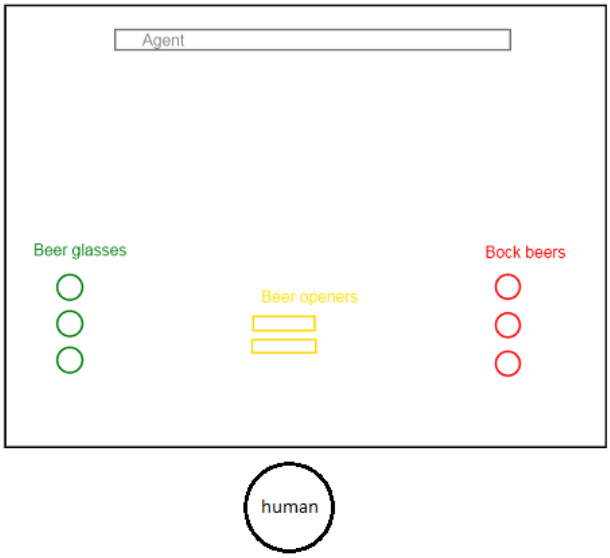

Figure 4. Scenario 2

3.2.3 Procedure

The test subjects were split into two groups. One group would do the two scenarios with head tracking and one group would do the two scenarios without head tracking. When a test subject entered the room the first thing was to fill the informed consent form. This form gave a short description about the experiment and some other formalities for example about the use of photo's. The test subject was asked to take a seat in the chair in front of the virtual human agent. The test subjects with an odd number were with head tracking and the test subjects with an even number were without head tracking. When the test subject was ready the virtual human welcomed the test subject and asked to listen carefully to the instructions. The instructions gave an overview of what the virtual human agent would do. The test subject would receive instructions from the virtual human agent and the task of the test subject was to perform the tasks as good as possible. The test subject was able to request for help during the experiment when something was unclear. The test subject was allowed to ask to repeat a scene of a scenario. The test subject was asked to move the head so that the effect of head tracking was noticed, whenever the test subject used head tracking. After the instructions the test subject had to perform tasks the virtual human agent gave according to two scenario's that were executed always in the same way (see figure 5). During this after every scene a snapshot was taken from above. After this the test subject had to fill in the questionnaire.

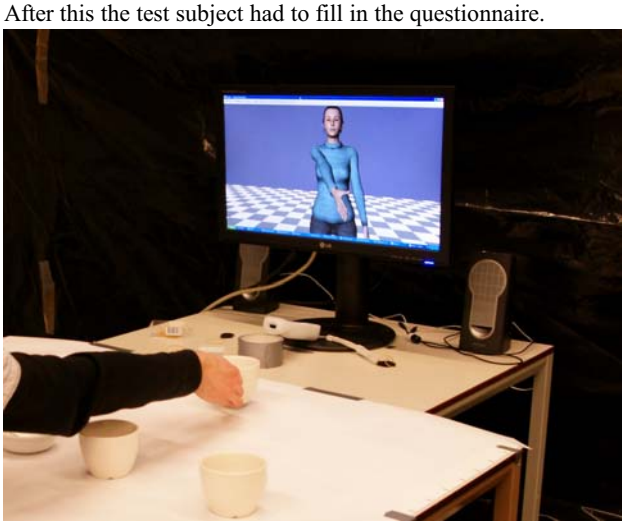

Figure 5. Performing a task given by Kenny

3.2.4 Measures

The questionnaire what was a main part of this research was developed during the research. For this research validated questionnaires were used. To find the right constructs it was necessary to find papers that suit this research. A few papers [4],[5] contained questionnaires that led to a suitable construct. It was also possible to create your constructs for this research that might suit the research even better, but due to time it was necessary to use validated questionnaires.

From all the constructs in these papers [4],[5] only a few could fit in. The constructs that would fit in required that it has something to do with realism and presence and that it would fit within the experiment. This in combination with some expectations resulted in eight constructs. A short overview of the used constructs are given in table 1. These are from validated questionnaires so with each construct a Cronbach alpha is given from the papers [4] and [5], that indicates whether the questions are from the same construct. A detailed description of each of the constructs can also be found in the papers [4] and [5]. The constructs were all related to realism and presence and for some of them this relation was shown in their paper.

Table 1. The eight used constructs from [4] and [5]

Code	Construct	Cronbach alpha	Amount of questions
ANX	Anxiety	0.812	4
AA	Attention Allocation	0.81	6
CP	Co-presence	0.84	6
PEOU	Perceived Easy Of Use	0.729	5
PENJ	Perceived Enjoyment	0.774	5
PTU	Perceived Task Understanding	-	4
SP	Social Presence	0.816	5
Trust	Trust	0.732	2

Perceived Task Understanding is a modified validated construct. The original construct was Perceived Message Understanding [4] with a Cronbach alpha of 0.87. Though not all the questions would fit in properly though it is an important part of the research to indicate if human is able to understand more of the task. The construct consisted of two questions from the validated construct and two questions that were important for this research. This resulted in the four questions in table 2.

Table 2. PTU questions

Questions
It was easy to understand Kenny. [5]
Understanding Kenny was difficult. [5]
I understood what Kenny wanted me to do. (new statement)
It was difficult to see where Kenny was pointing at. (new statement

4. RESULTS

In the experiment 31 questionnaires were filled. 16 questionnaires with head tracking and 15 questionnaires without head tracking. The test subjects were all students around the age of 18 to 30. Of these 31 questionnaires a Cronbach alpha was calculated for each of the constructs, using statistical analysis software namely SPSS. As a rule of thumb only the Cronbach alpha with 0.7 or higher can be used for analysis, all other questions need to be discussed individually (see table 3).

Table 3. Cronbach alpha

Construct	Cronbach alpha
ANX	0.549
AA	-0.135
CP	0.550
PEOU	0.464
PENJ	0.829
PTU	0.660
PTU (-1)	0.741
SP	0.899
Trust	0.748

The constructs of ANX, AA, CP and PEOU will require individual discussion. While PENJ, PTU or PTU (-1), SP and Trust can be discussed as one construct, because they have a Cronbach alpha above 0.7 and the Cronbach alpha is close to the validated Cronbach alpha's (see table 1). PTU (-1) has one question substracted namely the last question in table 2.

First we will take a look at the the constructs with a Cronbach alpha higher than 0.7. A t test is done to reveal a statistical reliable difference between the group with head tracking and without head tracking (see table 4).

Table 4. Means, standard deviation and t-test

Construct	Means	Standard Deviation	t test
PENJ *[1]	2.9250	0.78613	t(29) = 0.067, p=0.947
*[2]	2.9067	0.73627	
PTU (-1) *[1]	4.1042	0.84080	t(29) = 0.026, p=0.980
*[2]	4.1111	0.63828	
SP *[1]	1.8375	0.93301	t(29) = 0.319, p=0.752
*[2]	1.9333	0.71581	
Trust *[1]	2.9688	1.08733	t(29) = 0.006, p=0.995
*[2]	2.9667	0.91548	

*[1] = with head tracking, *[2] = without head tracking

With an alpha of 0.05 all t tests failed to reveal a statistical reliable difference between the group with head tracking and without head tracking.

The remaining constructs ANX, AA, CP, PEOU and the remaining question from PTU still have 22 questions. Though only a few of these questions are relevant for discussing them individually (see table 5).

Table 5. Remaining questions

Code	Question
V1	How would you rate your English?
V2	It was difficult to see where Kenny was pointing at. (PTU)

The relevant questions are those who reveal a statistical reliable difference between the two groups when taking an alpha of 0.05. Only there were no questions that showed an alpha lower than 0.05, thus discussing them would be irrelevant. Only a question about how somebody would rate their English and the question left out of the PTU construct are exceptions that will be discussed despite the alpha for completeness (see table 6).

Table 6. Means, standard deviation and t-test

Question	Means	Standard Deviation	t test
V1 *[1]	3.94	0.680	t(29) = 0.766, p=0.450
*[2]	4.13	0.743	
V2 *[1]	2.81	1.109	t(29) = 0.696, p=0.492
*[2]	2.53	1.125	

*[1] = with head tracking, *[2] = without head tracking

5. DISCUSSION

The results from the constructs show that there is no statistical reliable difference between the groups on a few constructs, namely PENJ, PTU (-1), SP and Trust (see table 4). This research expected some differences, especially in the area of performing tasks. In relation to task analysis [1] there is some measurable difference. Though in the perception of human it does not seem to add anything to enjoyment, better task understanding, social presence or trust. A reason for no measurable improvement, especially for PTU, might be that it is hard for human to estimate how well their own behavior was.

Possible reasons for a Cronbach alpha that is lower than 0.7 for the constructs might be the understanding of a question in case of this experiment. Some questions in the construct of ANX were a little bit exaggerated for Kenny was not really approaching the uncanny valley [2]. PEOU had questions that were hard to understand for some test subjects, which required some explanation during the experiment sometimes. The question could suggest that some could use Kenny on their own, while the technical equipment seems pretty heavy, though one also might think of using Kenny for personal use. Though when a test subject does not see why to use Kenny at all it makes it harder to answer such type of questions. The construct CP and AA had questions about the perception of Kenny towards the test subject and perception of the test subject towards Kenny. That might have caused a problem, because a test subject might think that the test subject kept his attention, though Kenny did not. The reason that the last question of table 2 did not fit in the construct PTU was because this was very specific. The main reason this was not in the PTU construct is because the voice of Kenny was found to be disturbing to a lot of test subjects.

A reason that no reliable statistical differences were measured could be that the experiment itself showed to less capabilities of head tracking towards human. In this experiment head tracking was not used so vividly. Most of the test subjects kept their heads straight and barely made use of head tracking to position the objects. During the creation of the measurement tools an issue occurred with the Elckerlyc software. Due to a built in clock a big drop in the frame rate was measured. The issue could only be partially fixed. This might have great influence on realism and reliable measurement. Though in what way it might have caused problems is not possible to conclude.

6. CONCLUSIONS

From the perception of human there is no significant difference found that shows that humans were influenced by head tracking. Although the constructs were expected to show differences, especially in the area of performing tasks. While analysis on the performance effects show a measurable difference [1], our research was not able to detect a difference from human perspective. The cause might be that humans still were very uncertain about how well they performed their tasks. Thus at the end from the perception of a human, viewpoint correction does not change enjoyment, task understanding, social presence or trust. Despite that there is no change, this research is able to contribute to science as a fresh start to more research. This is not based on the benefit head tracking has, but based on the growing possibilities nowadays with viewpoint correction [6] and the results on the performance effects [1].

Realism and presence were the main variables that needed research. For this indicate more interesting facts from the perception of human towards head tracking. Realism and presence in this paper were approached by different constructs (see table 1) that were found in validated questionnaires.

These questionnaires [4],[5] that were found during the research helped to build the constructs. Only the relevant constructs were necessary. By indicating what would fit in the experiment and what would help us to retrieve more information about realism and presence the relevant constructs were found. One construct required adjustment in order to fit in and gain knowledge about the pointing tasks (see table 2).

To gain as much relevant results the environment was studied carefully. In order to prevent realism and presence to drop the grid was made in a special way so not conclusions could be made about what was measured. Test subjects were instructed carefully and were selected to have barely knowledge on what the experiment was about. The whole experiment was the same for every test subject and that made it more constant. To prevent distraction simple scenario's were made, so this would not greatly influence the results. Later on during the experiment new influences of the environment showed up. The measurement setup itself influenced greatly what head tracking would add. A drop in the frame rate did influence realism and presence, because this problem was only partially fixed. Also the voice of the virtual human influenced the realism and presence. Another issue was that the test subject needs to estimate their own behavior, which could have been really hard.

Through statistical analysis it was able to determine the Cronbach alpha of constructs. The questions of some of the constructs were discussed individually while other constructs had a proper Cronbach alpha to be discussed as a whole. After that a t test was done to reveal a reliable statistical difference. The results showed no measurable difference.

6.1 Future research

Because the performance effects showed a measurable difference [1] and the growing possibilities of viewpoint correction [6] future research is still interesting. During this research some issues came up that require improvement of the measurement tools. For example the frame rate should be fixed to obtain more realism and presence.

For this research stereoscopic view might add an interesting area. Seeing depth when sitting quietly on a chair is really hard with viewpoint correction, though with stereoscopic view added it might result in more accurate positioning and maybe even give more realism. In the early beginning of the research stereoscopic view was supposed to be implemented, though due to time this was not added. A difference between vertical and horizontal picking of objects was measured [1], that indicated problems with depth seeing. Stereoscopic view and a better frame rate might give more results for this research using the same questionnaire.

The questionnaire can also be improved by creating own constructs and make them validated, without using modified and unmodified validated questionnaires.

The experiment allowed the test subject to sit around quietly and have no movement. Scenarios or an measurement setup that requires more usage of the capabilities of head tracking might give new insights.

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