# Camera Heights in Cinematic Virtual Reality: How Viewers Perceive Mismatches Between Camera and Eye Height

**Sylvia Rothe**
Media Informatics, LMU
Munic, Germany
sylvia.rothe@ifi.lmu.de

**Boris Kegeles**
Media Informatics, LMU
Munic, Germany
boris.kegeles@campus.lmu.de

**Heinrich Hußmann**
Media Informatics, LMU
Munic, Germany
hussmann@ifi.lmu.de

## ABSTRACT

When watching a 360° movie with Head Mounted Displays (HMD) the viewer feels to be inside the movie and can experience it in an immersive way. The head of the viewer is exactly in the same place as the camera was when the scene was recorded. In traditional movies, the viewer is watching the movie from outside and a distance between eye height and camera height does not create a problem. However, viewing a movie from the perspective of the camera by HMDs can raise some challenges, e.g. heights of well-known objects can irritate the viewer in the case the camera height does not correspond to the physical eye height. The aim of this work is to study how the position of the camera influences presence, sickness and the user experience of the viewer. We have considered several watching postures as well as various eye heights. The results of our experiments suggest that differences between camera and eye heights are more accepted if the camera position is lower than the own body height. Additionally, sitting postures are preferred and can be adapted easier than standing postures. These results can be applied to improve guidelines for 360° filmmakers.

## CCS CONCEPTS

• **Human-centered computing** → *Virtual reality*; • **Multimedia Information Systems** → *Artificial, augmented, and virtual realities.*


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## KEYWORDS

Cinematic Virtual Reality; 360° movie; presence, camera height, eye height

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## 1 INTRODUCTION

In Cinematic Virtual Reality (CVR) the viewer watches 360° movies using a Head Mounted Display (HMD) or other VR devices. Thus, the viewer is watching the movie from inside and the camera level is the viewer's perspective in the virtual world.

The height of the camera plays an important role in the composition of scenes in traditional movies. A high angle camera looks down on an object or character and the viewer usually feels more powerful. A low angle camera looks up and makes the object/subject in most contents more important [2]. This is also, even more, essential for CVR. Because of the new perspective in CVR-videos, the feeling of being smaller or taller depending on the camera position is stronger than in traditional movies. However, there are many situations in a story, where the viewer should not be influenced in such a way.

Furthermore, the eye height of a person is decisive for human perception. It is used for scaling sizes, velocities and distances [13]. Distances and heights of viewed objects are determined by using the own eye height. Therefore, a wrong camera position can lead to disorientation in the movie world. In 360° video guidelines, it is recommended to place the camera at head height [9, 16]. Because humans have different body sizes it is difficult to implement such advice. "The Cinematic VR Field Guide" [9] recommends a height of about 177cm. In scenes with protagonists, their eye height could be a helpful reference, as is done for traditional movies.

In addition to this visual source of sensory information, the postural information is important. Since the viewers have knowledge about their own posture (e.g. sitting or standing), this can affect the perception of the CVR experience. Since a shot usually is recorded in only one height, the filmmaker has to decide about the camera position.

We investigated which differences between camera height and own eye level are acceptable without irritating the viewer. It was explored if the height of the camera has an impact on presence, sickness and user experience. To answer these questions, short videos with several camera heights were produced. The first study examined the impact on the CVR experience when the camera is too high or too low. The results of our work show that people have less problems in the case the camera is too low than if it is too high. Differences of 10cm were accepted by most of the participants, even if the camera corresponding to their own eye height was preferred.

In a second user study, we explored which consequences a standing posture has, if a viewer is watching a scene recorded at sitting eye level - and vice versa. Placing the camera at eye level of a standing person suggests that the viewer should stand during watching such movies because otherwise the presence and the VR experience could be destroyed. In analogy, if the camera recorded at the eye level of a sitting person, probably the viewer should sit. The results show that sitting postures were preferred even if the camera had a standing position. To adapt a sitting posture is easier than a standing posture. We are convinced that these results are useful for further development of guidelines for 360° filmmaking and also for viewer recommendations.

## 2 RELATED WORK

**Eye Heights in the Real World**

In real life humans using eye heights for determining distances, object dimensions and perceiving affordances [19, 20]. Wraga has shown that eye height has more influence for determining heights of objects than widths. A reason for that is that both, the height of the object and the eye height, are specified in the vertical axis of the space [21]. This knowledge is important for CVR because heights of well-known objects can irritate the viewer in cases where the camera height does not correspond to the physical eye height. Researchers in medicine and psychology exploit virtual environments (VE) to study the influence of height on social behavior, life satisfaction and diseases such as paranoia [6, 13, 22]. A good overview how egocentric distances are perceived in VR is given in [18].

**Eye Heights in Computer-generated VR**

In computer-generated VR the user looks at the environment via the virtual camera and the virtual eye height of a person can be changed. Real-time camera control can be used for interactive narratives in virtual environments [1, 7, 10]. The height of a character relative to the user influences how a character is perceived. A taller character is supposed to be more dominant and stronger.

There are several investigations of how the virtual eye height influences the perception of sizes and distances in the virtual world [12, 14]. Leyrer et al. [13] investigated how users determine their own eye height in a virtual environment. Comparing visual and postural cues in virtual environments, they found out that humans rely more on postural cues for determining their eye height in the case there is a conflict between the visual and postural information. In experiments, it was shown that increasing eye height led to a decrease in perceived distance. However, a decrease in eye height did not influence perceived distance [12].

Controlling the virtual body size can reduce discomfort caused by inappropriate interpersonal distances. Maeda et al. [15] changed virtual body sizes in augmented reality environments. Varying the height of persons in the HMD resulted in different perceptions of the interpersonal distances. J.E.Cutting investigated how eyes measure reality and virtual reality [3]. For these nine sources of information were introduced: occlusion, relative size, height in the visual field, relative density, aerial perspective, binocular disparities, accommodation, convergence, and motion perspective. They are also important for our investigations. Occlusion (one object partly hides another) can change for varying camera heights.

**Eye Heights in Cinematic VR**

Since in CVR the content is not produced in real-time, rather recorded in advance, neither camera height nor character sizes can be adjusted for the viewer. The filmmaker has to determine the height of the camera when the scene is recorded. This height should fit for viewers of most body sizes and watching postures. To fulfill this with one camera height requires finding which camera heights are suitable.

There is less research about eye heights in Cinematic VR. Philpot et al. [17] compared the experience of watching a CVR video in CAVE-like and head-mounted displays. When the camera was higher than eye level, some users mentioned feeling tall. A camera lower than eye level resulted in feeling small. This finding is consistent with the knowledge about traditional movies. However, in the case of the high camera, some people felt a sense of vertigo, which was not the case for the low camera. Keskinen et al. [publication end of March, will be added for camera ready] showed that people who are very close to the camera and a very low camera can negatively effect the experience. In the studies of Passmore et al. [16] viewers complained if the camera was too high (about a meter higher than a normal body size), some of them felt dizzy. Additionally, they had to look down in this case and recognized that they had no body in this scene, which was not a problem when the camera was at eye height. For a setting with a very low camera (60cm), which was induced by the story, some users commented, that they felt too small, however without vertigo.

In our studies, we are interested in smaller distances between camera height and physical eye height, differences which result from diverse body sizes. We want to explore which distances are applicable without irritating the viewer.

## 3 FIRST USER STUDY: DISCREPANCIES IN HEIGHT

To investigate whether the height of the camera influences presence, sickness and experience we established three tasks. In the first task, we wanted to find out if the feeling of the user for their own height in virtual reality corresponds to the true body size. For this, a virtual environment was created in which the participants should find their own height. The second and third task were conducted for finding out if small differences between physical and virtual eye height irritate the viewer. We distinguished between a sitting posture (task 2) and a standing posture (task 3)

### Material

For identifying how the users feel their own height in a VE (task 1), an application with Unity (5.6.3) and the Pack Gesta Furniture #1 by Gesta2 was implemented. We created a VR living room where pieces of furniture in standardized sizes are reference objects for the height (Figure 1). An Android app for the Samsung Gear VR and a Bluetooth controller has been developed. The participants could change their eye levels in the VR room until the eye level feeling fitted to their eye level in reality. They could not move in the virtual room and were all at the same place.

**Figure 1: AVR living room for identifying the feeling of own height in a virtual environment (created with Unity and the Gesta Furniture Pack).**

For the other tasks we produced two short videos with different heights of the camera. The captured material has a resolution of 3.840 x 1.920 and a frame rate of 30fps.

We chose typical situations for sitting and standing postures. The first video was recorded in a sitting situation at a table in a cafè (Figure 2). A retired couple had a conversation with a young man. The scene was produced for several heights of the camera: 100cm, 110cm, 120cm and 130cm. We call the video sitting-video. The situation for all videos was the same, only the text of the conversation changed.

**Figure 2: The full $360^\circ$ image for the first video, a scene in a cafè recorded in a sitting height (the face blurring was not there during the study).**

The second video was recorded in a standing situation in a pedestrian zone (Figure 3). A football artist was juggling a ball while pedestrians watch. The scene also was produced for several heights of the camera: 150cm, 160cm, 170cm, 180cm, 190cm and 200cm. We call it standing-video. The situation for all videos is the same. However, there are different parts of the performance of the football player and the audience is partly changing.

All the videos were about 1 minute. We have chosen this short length because we were interested in the feelings at the beginning of a scene and assumed that the viewer can get used to mismatched heights. The videos had no emotional content since we were interested in the acceptance of the recorded environment in the chosen camera height. This should not be influenced by the story. After each video, a part of the questionnaire was answered in the real world (without HMD).

**Figure 3: The participant's field of view for the second video, a scene in a pedestrian zone recorded in standing height.**

### Questionnaire

Before the participants watched the movie, some general questions were asked: gender, age, height, VR experience. Participants without VR experiences were given a 5-20min time slot for playing around in a virtual environment which did not concern the study. The aim of this was to reduce the novelty effect.

*Presence.* To investigate the presence, we used parts of the presence questionnaire (IPQ) [8]. It contains three subscales which determine the spatial presence (the sense of being physically present in the VE), involvement (attention devoted to the VE, experienced involvement) and experienced realism (subjective experience of realism in the VE). Since the IPQ was developed for general virtual environments with interactivity and movement, we chose ten of the fourteen items which are relevant for CVR.

(1) I had a sense of "being there". (general)
(2) I felt that the virtual world surrounded me. (spatial presence)
(3) I felt like I was just perceiving pictures. (spatial presence)
(4) I did not feel present in the virtual space. (spatial presence)
(5) How aware were you of the real world? (involvement)
(6) I was not aware of my real environment. (involvement)
(7) I still paid attention to the real environment. (involvement)
(8) How real did the video seem to you? (realism)
(9) How much did your experience in the virtual environment seem consistent with your real-world experience? (realism)
(10) The video seemed more realistic than the real world. (realism)

*Simulator sickness.* For measuring simulator sickness, the items of the Simulator Sickness Questionnaire (SSQ) of Kennedy et al. [11] were used. Since not all questions are relevant for Cinematic VR, nine items were selected: (1) general discomfort, (2) fatigue, (3) nausea, (4) headache, (5) dizziness, (6) eye strain, (7) difficulty focusing, (8) difficulty concentrating, (9) loss of orientation. In this way, it was not possible to calculate the total score exactly as it is described in the original paper [11]. However, we received information to compare the different test options.

*User experience.* After each video, the participants were asked if they had a strange feeling in the movie and, in the case they had, they should describe it. Finally, after all the videos have been shown, the participants were asked, which video they preferred and which video was recorded in their own height.

### Participants and Procedure

26 Participants (17 males, 9 females), average age 33.2 (SD = 15.4) took part in the study. 73.1% of the participants had previous VR experiences. Before the tests started, we measured the body height and the eye level of the participants in standing and sitting postures. The average body height of the participants was 175.4cm (SD=8.89), the average eye level in standing posture 165.3cm (SD=8.91) and in sitting posture 122.1cm (SD=4.7). The chair had a height of 0.45cm. All participants started the sequence with the same viewing direction. Even if they could look around afterward and so the viewports differed, they mainly were focused on the subjects in front. The task was divided into three parts:

- In a standing posture, the participants had to change their own viewing height in a VR room until the height corresponded with their own height.
- Sitting on a chair two videos were shown recorded with different camera heights, one of them in the correct height of the participant (+-5cm), the other one 10cm higher or lower.
- In a standing posture, three videos were shown recorded with different camera heights, one of them in the correct height of the participant (+-5cm), the other one 10cm and 20cm higher or lower.

The participants were randomly separated into two groups and a between-subject design was applied. One group watched videos with setups higher than their own heights and the correct sitting height. We call it the taller-group. The other group watched videos beneath their own height and the correct height. We call it the smaller-group. The camera heights differed by 10cm. The test always started with the largest difference to eye height and finished with the camera on eye level. We decided to go that way since so the unfitting height is less noticable. The participants were not informed about the differences.

For the sitting part, the participants watched first a video 10cm above/beneath their own height and after answering some questions a video in the correct sitting size (+-5cm).

Since the eye level of standing persons varies more than that of sitting persons, we decided to investigate a bigger interval. For the standing part videos of 20cm and 10cm difference were shown and additionally the correct height. In our experiments we always started with the 20cm difference, followed by the 10cm difference and ended with eye level. After each video, parts of the questionnaire were answered.

### Results

*Estimating height in VR.* In the first part of the study, the participants determined their own height in a VR room. 42.6% of the participants matched it very closely (+/- 10cm). 80% of the participants identified the VR height smaller than their real height, 50% estimated their height too small (more than 10cm too small). Only two persons fixed it too high (more than 10cm too high). Both persons experienced VR for the first time and were very impressed by it.

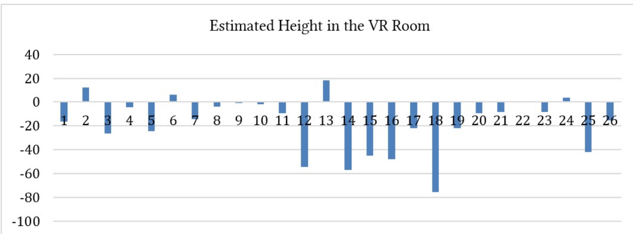
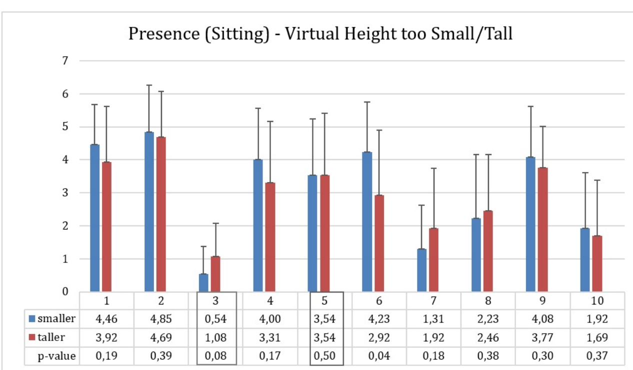



**Figure 4: The picture shows the differences between the estimated height in the VR room and the real height (in cm). Most participants ranked themselves smaller.**

*Sitting Postures.* In the second part of the study, we investigated the influence of different camera heights in sitting watching postures. There was no significant difference between the groups regarding sickness. For comparing the presence in a scene with a camera too low and too high, we performed a two-sample t-test for each item, which showed a slightly higher presence for the cases where the camera was too low (Figure 5). For the determination of significance, we have chosen a p-level of 0.1, as this work is a first approach to this topic and we wanted to avoid missing any interesting aspects. We call results with a p-value 0.05 < p < 0.1 weakly significant.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| smaller | 4,46 | 4,85 | 0,54 | 4,00 | 3,54 | 4,23 | 1,31 | 2,23 | 4,08 | 1,92 |
| taller | 3,92 | 4,69 | 1,08 | 3,31 | 3,54 | 2,92 | 1,92 | 2,46 | 3,77 | 1,69 |
| p-value | 0,19 | 0,39 | 0,08 | 0,17 | 0,50 | 0,04 | 0,18 | 0,38 | 0,30 | 0,37 |

**Figure 5: The picture shows the means and standard deviations for the presence questions in a sitting posture, where the camera position is 10cm above or below eye height. The presence is higher for the case, where the user is smaller than in the real world. There is a significant difference for item (6) and a weakly significant difference for item (3).**

For two questions there is a difference:

- I felt like I was just perceiving pictures (t=1.4, df=12, p=0.083, weakly significant)
- I was not aware of my real environment (t=1.8, df=12, p=0.041, significant)

Comparing the presence scores of the cases, where the camera was too high, with the baseline, where the camera was on eye level (+5cm), we found significantly higher values for the baseline in item (1)/p=0.03 and weakly significantly higher values in items (4)/p=0.08 and (7)/p=0.08. For the lower camera, the value was significantly higher for item (3)/p=0.05 and (5)/p=0.03. Surprisingly, there were also some differences in the baseline comparing the two groups. This can be caused by the fact that the perception depends on the initialization [4]. For item (5)/p=0.06 and (6)/p=0.01 the score for these items was better for the smallergroup. It needs more investigations if this result is really caused by the camera heights in the videos before. Maybe a sort of internal calibration occurred by watching the videos before.

Investigating the viewer experience, we found the following results: overall 53.8% of the viewers specified strange feelings when the camera did not correspond to their eye levels; 38.5% in the smaller-group, 69.2% in the taller-group with the higher camera (Figure 6, left). The exact Fisher test showed that there was a statistically weakly significant difference between the groups (p=0.09) watching the movie in the wrong height.


**Figure 6: The pictures show differences in the viewer experiences (in percent). Left: If the camera position is taller than the real eye height, more viewers indicate strange feelings than in the lower case. For the smaller-group, there is no significant difference to the baseline. Right: More than half of the participants missed the conversation when the camera was too high/low and even on eye level when the camera was lower before. More participants followed the conversation if the previous video was too high.**

Comparing the attention during watching the video, there was no significant difference between the groups when the camera was too high/low. Again, there was a difference between the groups, watching the baseline video. More participants followed the conversation in the video on eye level, if they saw a video with a higher camera before (Figure 6, left).

69.2% of the viewers preferred watching the video in their own sitting height, 53.8% in the smaller-group and 84.6% in the tallergroup (Table 1, above). In the taller-group all viewers recognized correctly which video was in their sitting height, in the other group 53.8% (Table 1, below).

**Table 1: The table shows differences in the viewer experiences (in percent).**

| Preferred Video | +-10cm | eye level |
|---|---|---|
| smaller | 46.2 | 53.8 |
| taller | 15.4 | 84.6 |

| Video in own height | +-10cm | eye level |
|---|---|---|
| smaller | 46.2 | 51.8 |
| taller | 0.0 | 100.0 |

The exact Fisher test showed that there was a weakly significant difference preferring the video in the own height (p=0.08) and a significant difference in identifying the video of the own height (p=0.007). For the smaller-group, the scores for both questions did not show a significant difference for one of the two videos. Indeed, a success rate of 53.8% when deciding between two videos could also be caused by chance. That suggests the assumption, that in sitting postures, the viewer does not recognize if the camera height is 10cm too low.

*Standing Postures.* In this part, the participants watched the video in standing postures for three camera heights. We performed a two-sample t-test for the two groups and found that the general presence is significantly higher for the smaller-group when the camera differs from the eye level: for 20cm difference t=2.05, df=12, p=0.026; for 10cm difference t=1.7, df=12, p=0.044 (Figure 7). The difference between the groups when the camera corresponds to eye height is not significant (t=1.28, df=12, p=0.11). Summarized, in our experiments, there was no significant difference for the presence between the case, where the camera was too high, and the baseline, as well as no difference for the case, where the camera was too low, and the baseline.

46.15% of the participants complained about the first video (20cm lower or higher than the real height) because the proportions were not right and only 20% about the second video (10cm lower or higher than the real height). Comparing the two groups, there is quite a big difference. 61.5% of the viewers had a strange feeling watching the video 20cm too high, while only half of them had this feeling for the video which was recorded 20cm too low (Figure 8). As for the attention part in the sitting test, the score for the baseline indicates a better result for the taller-group.

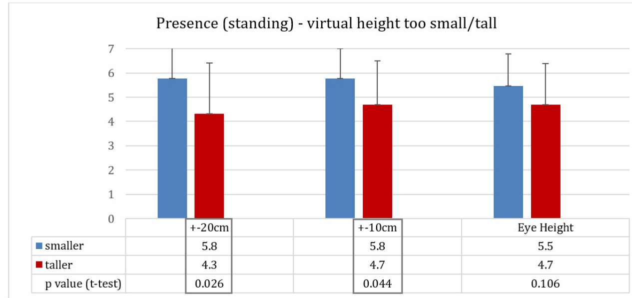



**Figure 7: For the general presence the means and standard deviations are significantly higher for the smaller-group if the camera differs 20cm or 10cm from eye level.**

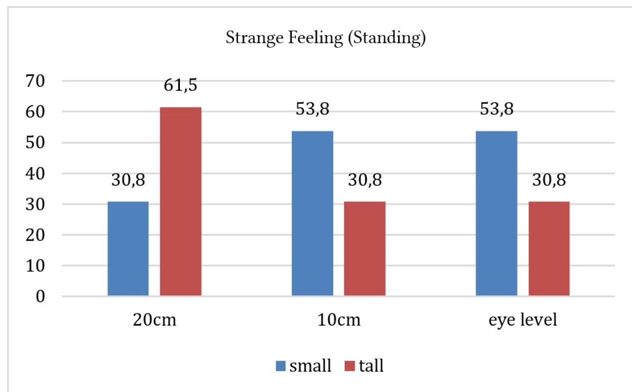



**Figure 8: The pictures show differences in the viewer experiences (in percent). Camera and eye height differ by 20cm and 10cm. In the situation where the camera position is taller than the real eye height, more viewers indicate strange feelings than in the lower case. There is also a difference between the two groups in the baseline case.**

In the shown video there is no conversation and we did not ask any attention questions in this part of the study.

Most of the participants, who watched the video higher than their eye level, (61.5%) preferred the last video, which corresponded to their own height. However, in the other group, only 23.1% said they liked their actual height video most (Table 2, above). For them, the difference was less important.

84.6% of the participants of the taller-group recognized the video which was recorded in their height, 30.8% in the smaller-group (Table 2, below).

The exact Fisher test resulted in a statistically weakly significant difference in having "strange feelings" (p=0.09) watching the movie in the wrong height. Additionally, there was a weakly significant difference preferring the video in the own height (exact fisher test, p=0.09) and a significant

**Table 2: Above: More viewers preferred the video of their own height when the camera position was too high. Below: More viewers identified the video of the own height when the other was too high.**

| Preferred Video | +-20cm | +-10cm | eye level |
|---|---|---|---|
| smaller | 38.5 | 15.4 | 23.1 |
| taller | 15.4 | 23.1 | 61.5 |
| **Video in own height** | **+-20cm** | **+-10cm** | **eye level** |
| smaller | 23.1 | 38.5 | 30.8 |
| taller | 0.0 | 15.4 | 84.6 |

difference in identifying the video of the own height (exact Fisher test, p=0.001).

### Discussion

In the first part of this study, the users estimated their own height in a VR room. In our results, there is a tendency for people to underestimate their own height. This can be caused by the fact that people are used to seeing the world from a lower perspective and so the world from this perspective is more familiar. We usually sit for long periods of the day. However, we used only one VR room and the result needs more verification. Additionally, all participants started with a virtual eye height, which was lower than the own height, which could have influenced the outcome, since ascending and descending adjustments often differences in thresholds [4]. This has to be clarified in future work.

Comparing the presence for the different heights, some items resulted in a higher score for the smaller-group. This outcome occurred in sitting postures, as well as in standing postures. Additionally, for both postures (sitting/standing) nearly twice as many participants had strange feelings watching the video with the high camera position. It is reasonable to presume that a too low camera is preferred over a too high camera.

Most people who watched the videos higher than eye level specified a strange feeling. In the case the camera was too low fewer participants reported it. There are several explanations for this. On the one hand, humans change their eye height in daily life very often. They are used to watch from lower positions. However, to experience the environment from a position higher than the body size is seldom. On the other hand, humans have grown up and had already seen the world as a smaller person.

Most of the participants of the taller-group could tell which video was filmed on their actual eye level and preferred the video which represented this height. Comparing both tests cases, sitting and standing, it is recognizable that this effect is stronger for the sitting posture, where all participants identified the video with their own height in the taller-group. This could be caused by the fact that in real life we can take different sitting postures with different eye heights, higher and lower than the normal sitting posture. However, there is seldom a standing position with an eye height higher than the normal eye height.

Against that, in the smaller-group, fewer people identified the video with their own height. The difference seems to be less important than in the taller-group.

We did not expect a difference in the baseline for the two groups. However, the presence was higher for two items in the presence questionnaire. Additionally, the attention was higher and the viewers had less strange feelings when they watched a too high video before. This outcome we will verify in future work.

With the results we can conclude that it is preferable to shoot a CVR video a bit lower rather than higher. The results show that the presence suffers less if the camera is too low. Also, the viewing experience is better in the case where the camera is lower. Our results agree with the statement that increasing eye height led to a decrease in perceived distance, but a decrease in eye height does not influence perceived distance [12]. Having a too low eye height seems to be a lesser problem than to have a too high level. Consequently, filmmakers should place the camera rather too low than too high. Based on an average body size of 1.76m (men) and 1.62m (women) [5], which result in an average eye height of about 1.66m (men) and 1.52m (women), a camera height of 1.56m is recommendable for standing situations. To give a recommendation for sitting situations is more difficult because it does not just depend on body height, but also of the seat height. In sitting situations induced by the story, e.g. sitting at a table, the surrounding items should be taken into consideration.

## 4 SECOND USER STUDY: DISCREPANCIES IN POSTURES

Since the filmmaker does not know if the viewer will watch the movie in a sitting or standing posture, it is important to know, how a movie recorded from a sitting posture influences a standing viewer - and vice versa. Using the same videos as in the first study, the participants watched the sitting-video standing and the standing-video in a sitting posture.

### Material

The setup was similar to the first study as again a Samsung Gear VR headset was utilized and the video material from the first study was re-used.

### Questionnaire

The questionnaire was very similar to that of the first study. The questions about the person, the presence, and sickness were the same. Additionally, the participants were asked after both videos if they had desired to change their pose during watching (from sitting to standing or vice versa).

### Participants and Procedure

Twenty participants (12 males, 8 females) watched the movie via HMD, average age 32.15 (SD = 11.3) and average height 179.4cm (SD = 9.75). 65% of the participants had VR experiences. People who had participated in the first study were not allowed to attend the main study as well, because they had already seen the videos. Every participant watched two videos:

- The cafè video recorded in the sitting height was watched in a standing posture. The camera height was 120cm because in the first study this was the eye level of all participants when they were sitting (+/-5cm).
- The football video recorded in the standing height was watched in a sitting posture. The camera height was 170cm.

A within-subject test design was chosen. The order of the videos was counterbalanced. After each video, the participants filled out a questionnaire regarding presence, sickness, and experience.

### Results

There were no significant differences regarding sickness and presence. However, more people specified a strange feeling of not having the right height, when they stood (Figure 9, left). Only a few people desired to stand up for watching a video recorded on a standing level. More people wished to sit down watching a video recorded on a sitting level (Figure 9, middle). Asking which of the videos was more difficult to watch, 55% chose the sitting-video and 30% the standing-video (Figure 9, right).

This time, the exact Fisher test did not show a statistically significant difference in having "strange feelings" (p=0.21) watching the movie in the wrong height. However, the desire to take the right posture was weakly significantly higher for the standing persons (exact fisher test, p=0.06). All participants had the opportunity for general comments about the CVR experience. P2 mentioned after watching the sitting-video in a standing posture: "Compared to the other video I felt smaller, but not disproportionately graceful (in contrast to the Giant feeling)". For P13 and P11 it was odd, to have the feeling sitting on a table with strangers, and P9 wished to feel the table. Other participants mentioned the unusual position (P5, P6, P8). Regarding the standing-video in the sitting posture, all remarks concerned the not suitable view

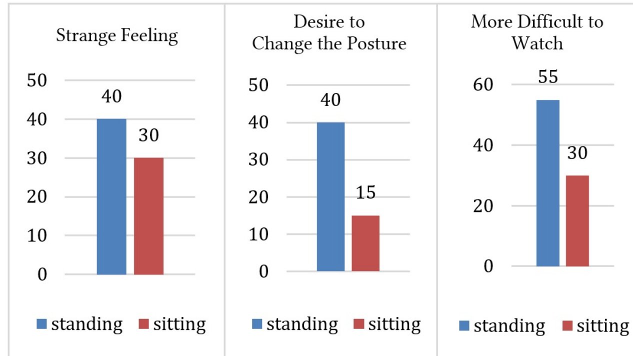



**Figure 9: Standing people watched a video with the eye height of a sitting person and vice versa. Left: number of participants (in percent) with strange feelings during watching the video. Middle: number of participants (in percent) who had the desire to change their posture. Right: for more people, it was difficult to watch the sitting-video in a standing posture as the standing-video in a sitting posture (in percent).**

(P2, P4, P9, P10, P12, P14). P2 mentioned a "strange feeling in the stomach" and P14 a distortion.

### Discussion

More participants preferred to sit down instead of standing up. For the participants, it was easier to adapt a sitting posture to a virtual standing position than vice versa. This is consistent with other research investigating the influence of eye height in virtual environments [12].

In our study, the viewers had the desire to change their posture and to sit down, when the camera height has a sitting level. The fact, that it is more comfortable to sit than to stand, could have influenced the result. Additionally, viewers are used to sitting down for watching movies.

The videos were about one minute, so this consideration should not have a big impact, but probably even more people would prefer to sit down when the videos are about 10-20 minutes long. However, the trend for sitting down, even for a short video, could be valid, for all heights of cameras. For further investigations, this should be taken into account.

The results show that the viewer is able to adapt a sitting posture, even if the camera is in a standing position. It is more difficult to adapt a standing position to a camera in sitting height. Therefore, it is beneficial, if filmmakers place the cameras at the eye level of a standing person. This position is comfortable for most users in standing postures as well as sitting.

## 5 LIMITATIONS AND FUTURE WORK

In our work, we used non-stereoscopic videos, because currently most 360° videos are filmed monoscopically. However, more and more cameras with stereoscopic options are coming onto the market. Using stereoscopic images can result in other outcomes, and further research is needed for such CVR movies.

The videos shown in the user study were very short. It is possible that users get used to a camera height that differs from the user's eye height. However, for filmmakers, it is important to know, how the viewer is feeling in the first moment after a scene has changed. Our user study does not cover a large amount of video content. We had only two different scenarios and the content may have affected the results. The results show that more viewers prefer to sit down when they are standing and watch a movie recorded in a sitting posture rather than vice versa. For investigating this we used a scene at a table in a cafè, where the people are very close to the viewer. Where in the football scene the main character is further away. It needs more research for several scenarios, especially if distances to objects and persons influence the acceptance of diverged eye heights.

The order of the cases was not permuted. We always started with the largest difference between eye and camera height and finished with the camera on eye level (baseline). In this way, we could discover differences in the baseline case depending on whether the camera height has increased or decreased. We did not expect that and will investigate it in the future.

Since a sitting posture is also more comfortable for other reasons, we want to focus our future research on this case. It seems not only the height of the camera influences the perception of the diverged heights of camera and eyes. Also, distances, movements, and affordances should be considered.

Some of the participants have never watched a movie via HMD before. Even for the others, viewing behavior can change over time, consuming more CVR videos. Unusual views can be acceptable having more experiences.

In this work, we examined camera positions close to the own height for a standard movie sequence, not to use small or tall heights to create sensations. However similar to traditional movies, a camera farther away - higher or lower - can be used as a stylistic element which should be explored in the future. It is important to know how different camera heights can support storytelling.

## 6 CONCLUSION

This research was our first step for investigating which camera heights and viewing postures are advisable in Cinematic VR.

Users prefer to sit down when watching videos, in particular, if the camera height corresponds to the eye height of a sitting person. As our results show, most viewers are able to adapt their sitting posture to a camera height on a standing level. This corresponds to the result of Leyrer et al. [13] about the importance of postural information for determining eye height. In our study, more participants had less problems to sit while watching a movie which was recorded in a standing height as vice versa. Videos recorded in standing heights are comfortable for most users in sitting postures, as well as standing. However, it seems to be more difficult to watch a sitting-video in a standing posture. Assuming that viewers are sitting while watching movies, filmmakers can place the cameras in sitting as well as standing positions, depending on the story.

Regarding fewer differences between camera and eye level, as sitting and standing, we found that camera positions lower than the viewer's eye level, lead to fewer difficulties than higher camera positions. Accordingly, filmmakers should place the camera rather too low than too high. Taking into account various body heights the camera position should be oriented to smaller persons since it is easier to adapt lower camera heights.

It is generally accepted that the relatively new medium Cinematic VR needs a new language for telling the stories. Neither the language of traditional filmmaking nor of computer-generated VR can be adapted directly. The height of the camera is only one instrument which has to be considered together with all the other instruments. Our research is one step in this direction.

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