There Is No First- or Third-Person View in Virtual Reality: Understanding the Perspective Continuum

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ABSTRACT

Modern games make creative use of First- and Third-person perspectives (FPP and TPP) to allow the player to explore virtual worlds. Traditionally, FPP and TPP perspectives are seen as distinct concepts. Yet, Virtual Reality (VR) allows for flexibility in choosing perspectives. We introduce the notion of a perspective continuum in VR, which is technically related to the camera position and conceptually to how users perceive their environment in VR. A perspective continuum enables adapting and manipulating the sense of agency and involvement in the virtual world. This flexibility of perspectives broadens the design space of VR experiences through deliberately manipulating perception. In a study, we explore users' attitudes, experiences and perceptions while controlling a virtual character from the two known perspectives. Statistical analysis of the empirical results shows the existence of a perspective continuum in VR. Our findings can be used to design experiences based on shifts of perception.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**; **Virtual reality**.

KEYWORDS

Virtual Reality, First Person, Third Person, Perspective, Embodiment

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1 INTRODUCTION

In classical desktop games, a character that represents the player is manoeuvred through a virtual environment by controller input. Traditionally, there are two ways in which the camera is located with respect to the virtual character: First-Person Perspective (1stPP)—the player is seeing through the eyes of the character, and third-person view or third-person perspective (3rdPP)—the player views gameplay from a point behind the character. Changing perspectives is an important tool in the hands of game designers, allowing them to influence the player's relationship with the character [7] and involvement [8]. The perspective is often a defining feature of a game and changing perspectives have inspired entire game genres (e.g., first-person shooter such as Doom; and third-person role playing games and action-adventure such as Metal Gear Solid). 3rdPP in traditional computer games is one of the most common design choices, and depending on the game design, goals and artistic expression can give advantages to the player and offer a different point of view on the game itself [7]. While 1stPP promises closeness to a "normal" perspective and more direct representation, with 3rdPP the character is a surrogate for the player's role in the virtual environment [51]. Yet, the notion of perspective remains unexplored in the case of Virtual Reality (VR) experiences.

In contrast to traditional desktop games that rely on controller input, in VR games a player's body and head movements are tracked and incorporated into the rendering of the virtual world and used for interaction. Typically, VR-games are played from a 1stPP. The player sees the virtual environment through the eyes of the character. Hands, for example, are often represented by virtual hand models or controller models at the same position as they would appear in real life. This is to create a sense of presence and embodiment. While 1stPP is the dominant interaction paradigm in VR, designing only 1stPP experiences is limiting. Focusing on 1stPP not only makes it impossible for players to choose which perspective they prefer for a particular game, but also limits the use of perspective shift as an artistic expression, and thus offers a lower variety in virtual experiences. Consequently, there is a need for HCI to **understand how different perspectives affect our experience of VR**. Further, we need to **understand if and how VR applications can make effective use of perspective shifts**.

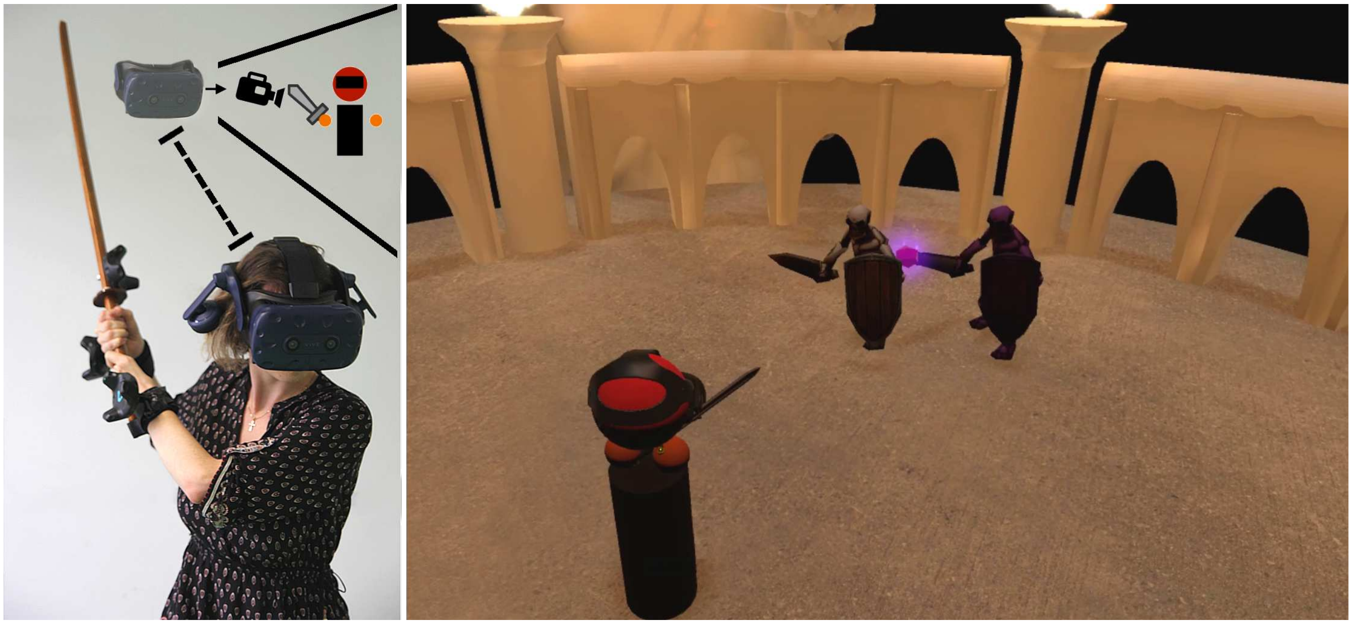


Figure 1: The presented scene (right) depicts the actual point of view of the VR user visible in the HMD (left). The concept of 1stPP and 3rdPP as known from traditional desktop games cannot be directly translated to Virtual Reality. While some users will perceive the scene as watching themselves from behind (similar to an out-of-body experience), others will perceive the scene as looking at another character that they control via their movement. Various design elements such as visualisations of the user's body and control schemes can impact this perception.

HCI has an established interest in understanding how users perceive virtual environments. VR systems allow the user to enter alternate realities where it is possible to experience out-of-body experiences and feel ownership of a body part that is not one's own [40], or to perceive one's own body from the outside [3]. Past research had shown that different factors such as visual quality [55], the form of representation of one's own body [45], and interactivity [36] contribute to the perceived quality of a VR experience. Yet, past studies in HCI used a single perspective when evaluating VR environments. Consequently, it is important for understanding the experience of VR to consider perspective as a factor contributing to the overall user experience and perceptions of embodiment. **Our work investigates how perspective affects the users' perception of a VR scene**.

This paper investigates how users experience virtual reality presented in different levels of 1stPP and 3rdPPẆe investigate how an exposure to 1stPP and 3rdPP affects presence and embodiment and study the interplay of scaling the camera height and environment. Our results show that while technically 1stPP and 3rdPP can be realised they do not align with what participants experience when gaming in VR. The perspective is not a discrete feature of a virtual environment (unlike in desktop games). Instead, it is perceived as a continuum. We provide empirical evidence for the existence of such a continuum and discuss its implications for future VR systems. In this work, we contribute the conceptualisation of a perspective continuum in VR that is supported by data from a user study. We also make recommendations for a common terminology for the perspective continuum in VR.

2 RELATED WORK

Our work is inspired by past research which investigated the role of perspective in games. Further, our work extends our understanding of the notions of self-location, agency, and embodiment in VR. In this section, we relate our study to past research efforts.

2.1 Perspectives in games and VR

According to Denisova et al. [7] 1stPP and 3rdPP are the perspectives that are most commonly used in desktop video games. 1stPP typically creates a better embodiment in the game, whereas 3rdPP gives the player a better overview of the scene [7]. In 1stPP VR games, just as in traditional desktop video games, players are positioned 'inside the character'. This provides the opportunity to perceive the world as if the user were the character, observe the world around through the character's eyes with a clear view of the scenery around the player [52]. HMDs enhance this approach by providing players with the ability to immerse themselves fully into a virtual world and freely observe it by rotating or moving one's head. Thus, 1stPP is most prominently used in VR games to enhance presence and embodiment of the simulation and identification with the character [49, 50]. In contrast, 3rdPP allows players to observe the main character from a distance instead of through the character's eyes [52]. The design of HMDs and the possibility of reacting to head motion results in 1stPP being the dominant design choice for VR experiences [53]. Consequently, 3rdPP has rarely been used in VR games, and thus, there is limited empirical evidence on the effects of 3rdPP in VR games. However, 3rdPP in VR—much like

3rdPP in desktop games—could produce an enjoyable gaming experience as it can give a larger overview of the environment [26] while maintaining high levels of presence [14] and low levels of motion sickness [35]. 3rdPP in VR does not facilitate navigation in the virtual environment when obstacles are in plain sight as efficiently as a 1stPP VR [34]. Still, if players are given the choice, moving actions are typically preferred from a 3rdPP and 1stPP is used [41] for more fine-grained actions. An answer to the question of what perspective is preferable could be to fully relinquish camera control to the user. Kosch et al. explored the optimal viewpoint in a mixed reality navigation task using an HMD and external cameras and found that an automatic camera is more effective than manual adjustments [27]. These examples show that the role of perspective in VR and the ways in which the camera can be controlled in VR experience have not been explored in a systematic way. Our work attempts to bridge that gap by comparing different perspectives in VR and the users' perceptions of those perspectives.

As of yet, only a handful of games have embarked upon the challenge of using 3rdPP in VR. For example *"Lucky's Tale"* (2016 by Playful Corp. [11]), a Jump and Run platformer, where the player controls a fox, needing to collect items and fight enemies while traversing through levels. The player views the levels and character from a 3rdPP while controlling the character via a gamepad. While traversing through the level, the player's viewpoint follows the character at a distance while floating through the level. While this gives the user close ups over new obstacles as the level progresses, the floating viewpoint can cause motion sickness [16, 35, 39]. Other games such as *"Astrobot"* [30] utilise a puppeteer-like camera perspective while controlling a character. While being similar to "Lucky's Tale" in game design, Astrobot places the player not only as a floating viewpoint into the world, but places the player into a character that looks down onto the level. Letting the player not only control the character via button presses on a handheld controller, but also interact with the world directly by helping the smaller 3rdPP character across a gap or by breaking down walls as the bigger 1stPP character via motion tracking of the handheld controller. Technically, Astrobot provides 3rdPP controls from a 1stPP, akin to a puppeteer looking at puppets. Similar game designs, such as controlling a character via a joystick-control and viewing them from a 3rdPP, have been implemented in titles like *"Trover Saves The Universe"* [13] and others [9, 12, 19, 31]. In these examples, the player is looking onto the scene in what can be described as a 1stPPand the characters themselves are viewed from a 3rdPP. The player often controls these characters via a gamepad. Therefore, the physical movement of the player is only reflected in the movement of the virtual camera and thereby a change of the viewpoint, rather than by the character's movement. The player views the scene either from a static camera position or from a tracked camera position which follows the character as it moves through the level. However, the player's body movements, such as raising an arm, are not reflected by the character, and character locomotion is kept separate from the player's movement in physical space. Thus, while some games did use 3rdPP in VR, that use implied not using the motion-based controls, which are a key design asset in VR. It remains an open question if and how direct motion control can be used together with 3rdPP and how such interaction will be perceived by users.

Another creative example of the use of 1stPPand 3rdPPis the VR game *"Fisherman's Tale"* [5, 10]. The game challenges the player's perception of 1stPP and 3rdPP by confronting the player with multiple representations and perceptions of their own virtual body. Upon the start of the game, the player explores a fisherman's hut in 1stPP and can grab and move objects via game controllers. The player can see a miniature model of the fisherman's hut sitting on a table. After lifting the model's roof, the player finds a miniature representation of themselves inside the hut. The miniature representation reflects the player's movements. After observing the room, the player notices that the 1stPP avatar itself is just a puppet inside a dollhouse and that there is a giant character outside of the hut who is also mimicking the physical movements of the player. The player, therefore, views the scene from 1stPPbut sees a smaller version of the fisherman inside the model and large one outside the hut in 3rdPP. Both 3rdPP characters are simultaneously mimicking the player's movements. Therefore, the player controls all three representations with physical movements and interactions while being presented with both a 1stPP and a 3rdPP. The Fisherman's Tale represents a unique example of how perspective manipulation in VR can be used as a design resource for creating engaging VR experiences. In our work, we experimentally explore the possibilities which perspective shifts offer to designers and how these change the users' perceptions of the VR scene.

2.2 Self Location, Agency and Embodiment

Embodiment is recognised as a key design goal for VR systems. Embodiment emerges when a person treats properties of a virtual body as those of their own biological body [25, 32]. This means that the body schema is updated and extended to the virtual body. Embodiment can be classified into three aspects [25, 29, 32, 33]: Self-location: a volume in the virtual environment where a person feels located at (i.e. biological body vs. avatar); Agency: when physical motor behaviour is appropriately translated into movement of the virtual body; and Body ownership: self-attribution of the virtual body. While technological advancements can increase agency and self-location, this is not the case for body-ownership. For example, an increase of agency induced by accurate motion tracking has been a primary factor in the recent advance of VR-systems for gaming. Contrary to that, body ownership is determined by multiple factors such as morphological similarities between the player and the character or visuo-tactile correlation [44].

Past work discussed how body ownership was facilitated by 1stPP and supported by the correlation of locomotion and visual flow [38]. However, we argue that this may only be partially true. Out-of-Body experiences suggest that body-ownership and viewpoint can be disentangled [25]. Also, in the rubber-hand illusion, the person sees a rubber-hand being touched by a tool, e.g., touching a hand with a pen, while synchronous tactile stimulation is applied to the person's hand [32]. This visuo-tactile correlation then creates a sense of body ownership for the hand (e.g., hitting the rubber-hand with a hammer will make the person withdraw his hand quickly). This can be extended to virtual limbs [21, 28], but can also be achieved for a whole virtual body, e.g., to reduce racial bias [37] or create empathy in violent offenders [47]. The use of virtual bodies are not only limited to one's own hands but allows for the use of remote or even multiple hands [42]. These works illustrate how body ownership can be a design dimension for VR experiences. It is important for designers to be able to influence embodiment to produce a range of reactions in users. Our work explores how perspective can be used to manipulate embodiment.

3 METHOD

In this paper, we study users' perceptions of 1stPP and 3rdPP in VR. We also investigate how the different perspectives can affect the user experience of VR systems. The user study compares 1stPP and 3rdPP in an example VR scenario. We hypothesise that the distinction of 1stPP and 3rdPP in VR is not discrete and that users perceive a continuum of perspectives. We argue that even when using 3rdPP the design characteristics of a VR scene are perceived from a 1stPP due to the nature and use of VR technology.

3.1 The Experimental VR scene

For the purpose of the study, we created a game-like VR environment where the participant's task was to defend themselves against skeletons with a sword. The game environment features a round arena built in a Roman style. The floor of the arena is a sand texture and is surrounded by an archway. The arena itself is well lit by several fires placed on pillars outside the arena. The world behind this central play area is blacked out.

We implemented a reward mechanic in the scene to keep participants engaged in play. Outside the arena, on the side which the player is facing, there is a large Roman statue holding a bowl. The bowl contains emeralds equal to the number of emeralds the player currently holds throughout the game. We decided to create a fun and exciting environment so that the participants got more invested in the world and cared about the fate of the character. We used emeralds as motivational elements that guide and animate the player, as known from many traditional games. The emeralds are dropped by different game entities and can then be collected. However, when the character takes damage, some of the collected emeralds are lost. This shows players throughout a session how successful they have been so far and provides a motivation to avoid getting hit. This concept is widely known from traditional computer games such as the golden rings from *"Sonic"*. While the player loses emeralds whenever the character is damaged, the character cannot die. We decided to remove the ability to die by being hit, as it may have caused frustration.

We chose a minimalist and neutral character design to make all participants more inclined to accept the character as their own body [18, 44, 46]. While the head of the character was mapped to the user's head-rotation and had an identifiable front due to the attached virtual HMD, the body was a cylinder without any orientation. This omnidirectional body representation eliminated the need for additional tracking to accurately display differences in body and head rotation. Both hands were tracked and represented by spheres. The sword prop was represented by a virtual sword. In our 3rdPP design, the user directly controls the characters by moving through the physical space and not via the use of a gamepad. The character follows the user's movements when, for example raising, the left arm. When the user moves, the character will also move forward, and rotate its head, etc.

3.2 Conditions

The study used two factors: the **perspective** and the camera setup and, therefore, the user's, **size**. The perspective was either set in a classical VR design (1stPP) or the camera was positioned behind a character model that mirrored the movement (3rdPP). In 3rdPP the camera is placed behind the character (the character is always the same size as the skeletons). In our design the participant has direct control over the character. The character, therefore, mimics the participant's behaviour (changing position, head rotation and sword movements).

Most traditional VR games place the player at the same size and scaling as the virtual surroundings to replicate the known perception of the real world (see Figure 2: 1stPP - Normal)[1]. This lets the players interact with objects or other persons that are the same size as themselves. 3rd Person VR games (e.g., Moss [2]) often raise the camera position above and behind the player character, therefore creating a scaled down miniature world. This form of 3rd Person VR games often recreates the scaling and aesthetics of the player standing in front of a tabletop game or diorama by placing the virtual floor at hip or breast level (see Figure 2: 3rdPP - Diorama), instead of placing the virtual floor at the same level as the real world floor (see Figure 2: 3rdPP - Giant). Making the player (as an observer) feel taller could lead to a different perception of the scene, e.g., smaller enemy characters may be perceived as less of a threat for the player than player-sized characters. In 3rdPP conditions the character model stays the same size as the skeletons. Therefore, to make the different design aspects of the two common VR designs – 1stPP - Normal and 3rdPP - Diorama – more comparable in a full study design, we included the conditions Giant. In these conditions the taller viewpoint of Diorama conditions are combined with a virtual floor that is placed at the user's feet as in the Normal conditions.

Therefore, to further explore different perspectives in the form of scaling and the placement of the camera we chose three different camera setups: normal, diorama (tall but floor at hip level), and giant (see Figure 2).

For 1stPP, this represents scaling of the participant in the scene. For 3rdPP this represents the distance to the character model. Normal height puts the participant as the same size as skeletons and character. Diorama raises the camera to a higher position while the skeletons and character remain small, and the floor appears to be at the height of the participant's hip, similar to a diorama or games such as "Moss". Giant uses an even higher camera position and scale and the floor appears at the height of the physical floor. The traversable virtual space is limited by the physical tracking space. However, the walking range for the user scales with the user's size depending on the size conditions. The bigger the user, the larger the steps they can take. While the camera in 3rdPP has the same movement characteristic as the user in 1stPP, the character in 3rdPP has an increased movement range. This means in 3rdPP, the further away from start point the user walks, the greater the distance from the character to the user. This allows the user in 3rdPP to orbit

[1] Number of applications on Steam: 1372 tagged with VR + First Person vs. 146 tagged with VR + Third Person (Data retrieved on 01.2022)

[2] https://en.wikipedia.org/wiki/Moss_(video_game) - Last accessed: Jan 2022

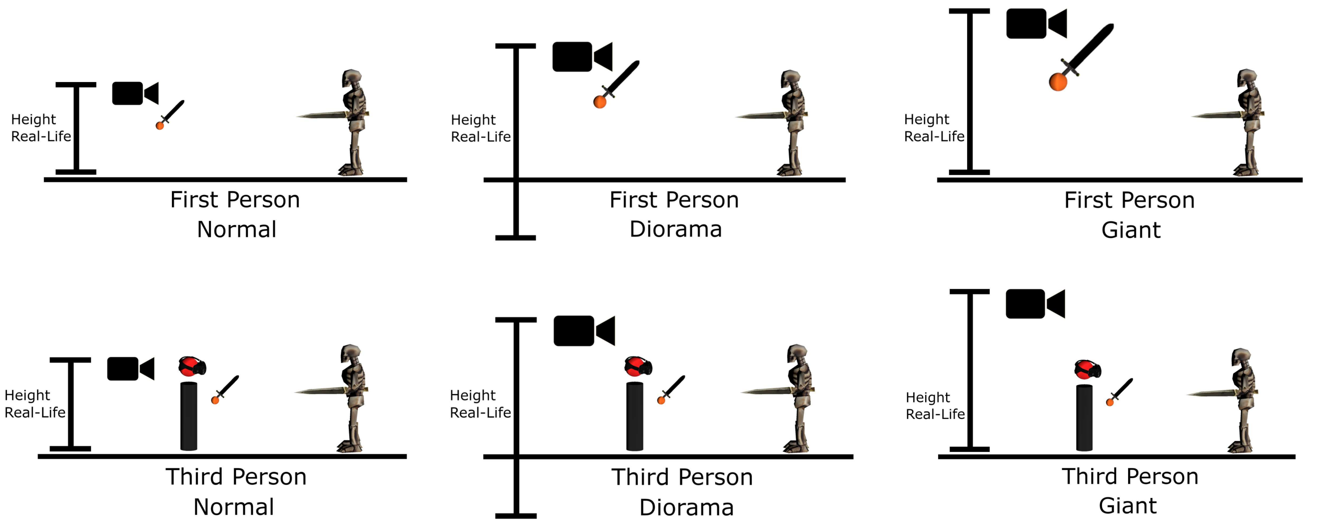
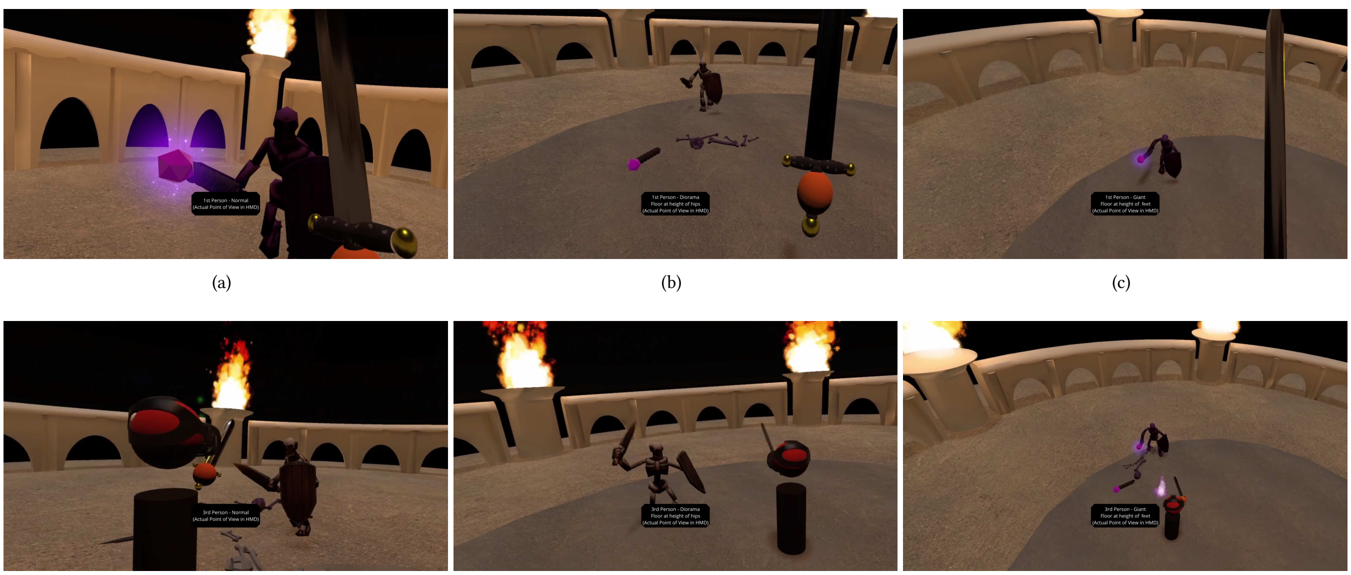


Figure 2: For the study we used a two level design: 1) perspective (1stPP and 3rdPP) 2) camera setup and scaling (Normal, Diorama and Giant) See Figure 3 for in-game perspective as presented to the participants.



(a) (b) (c)

(d) (e) (f)

Figure 3: Views of each condition (see Figure 2) as presented to participants: 1st Person Perspective (a,b,c) and 3rd Person Perspective (d,e,f) for camera scaling Normal (a,d), Diorama (b,e) and Giant (c,f). As size and distance cannot be well conveyed on paper, we recommend watching the video accompanying the paper to gain a better perception of each condition.

the character around the camera without losing sight due to the necessary head rotation.

We counterbalanced the order of conditions regarding the used camera setup. However, as we expected legacy bias and users expecting traditional 1stPP in VR if they had experienced VR before, we always started with one of the 1stPP conditions to help them adjust to the VR scene. After the initial exposure the order of perspective conditions was alternated between 1stPP and 3rdPP.

3.2.1 Task and Procedure. After welcoming the participants, they were introduced to the governmental and university set safety rules and procedures regarding COVID-19. At the beginning of the study, participants received a short verbal overview of the study procedure. After giving informed consent for the participation in our study, they were asked to complete a questionnaire consisting of demographic questions. A short explanation of the use of the HMD was given. Throughout the study, we tested for potential motion-sickness with the use of a fast motion sickness scale introduced by Keshavarz et al. (2011) [24] which measures general discomfort with special focus on nausea on a scale from zero to twenty. Between the conditions, we prompted participants to rate their individual level of motion sickness using this scale.

Participants were placed in an arena and asked to defend themselves against attacking skeletons for 3 minutes. They had an additional 1 minute to get used to the perspective (once per 1stPP and 3rdPP). There were two types of skeletons, sword wielding and wizards shooting magic arrows, that spawned in a random pattern in the forward facing area of the starting position of the player (180°). The spawn area was limited so that no skeleton was spawning in the area behind the character, thereby removing the need for the participant to stand with the back to the 3rdPP character and not being able to see the character's movement while performing a sword strike backwards. As we were not interested in performance evaluation or possible advantages of 3rdPP over 1stPP, we chose this limitation to help the participant to focus on the character, as this is the main focus of the study. The sword wielding skeletons walked towards the character to get in melee range. The wizard skeletons kept some distance from the character. The participants were tasked with defending themselves against the skeletons while trying to not get hit. To simulate a sword blow they had to hit the skeletons at a certain speed. Depending on the condition, the skeletons either targeted the camera (1stPP) or the character (3rdPP). The player lost emeralds (as a representation for health) whenever the character was damaged, but the character could not die.

3.3 Apparatus

The participants entered the scene inside the arena which was created with Unity3D. We used Windows 10 PC with an i5-7500, GTX1080 and 16GB RAM to run the VR environment. The scene was presented on an HTC VIVE Pro VR HMD. We mounted an HTC VIVE tracker on a Bokken style wooden sword (750g; 101cm x 5cm x 5cm). The tracker was placed above the tsuba (crossguard) (see Figure 4).

3.4 Measures

We administered four measures during the study using questionnaires that were presented after each condition. We decided against using in-VR questionnaires as the completion of these would be perceived from a 1stPP and therefore cause a shift in perception. The first ten questions were the embodiment questionnaire by Gorisse et al. [16]. We chose this questionnaire to assess the impact on embodiment that a perspective shift between 1stPP and 3rdPP might have, e.g., seeing the 3rdPP character as a separate entity or feeling connected to and embodied into the 3rdPP character. Next, we asked 14 questions from IGroup's Presence Questionnaire (IPQ) [43]. We chose this well-established questionnaire to compare the level of presence across conditions. We included the *in-game version* of the Games Experience Questionnaire (GEQ), a concise version of the core module of the GEQ to assess overall experience rating including immersion, flow, competence, positive and negative affect, tension and challenge [20]. We chose to add the GEQ as it is well established in the community, to increase the comparability of our results and allow for insights on whether the game experience was affected by the presented conditions. This also allowed us to eventually control for cases the gameplay could be less pleasurable due to the perspective shift. Additionally, we designed three questions focusing specifically on the perceived perspective and relation to the character: We asked the following questions to investigate if the physical relation and distance to the character is perceived differently by each participant or if the level of embodiment affects this, e.g., a higher level of embodied in the 3rdPP character leads to the perception of standing closer to it. *"How large was the distance between camera position and virtual body?"* and *"How large was the virtual body's height?"* To investigate if the scene was perceived as either 1stPP or 3rdPP we asked for a response to: "I felt that I was in the body of the..." accompanied by a visual continuous scale (see Figure 5). The participants were asked to place a mark along a continuous line with a visualisation of the character with a camera symbol next to it. An arrow highlighted the character on the left side and the camera on the right side. This was chosen in an effort to represent the concepts of 1stPP and 3rdPP without the need of previous knowledge about the designs and also to avoid priming participants based on their previous experience with these designs. To avoid potential bias we paid attention to the framing of the questions and used neutral terms such as "virtual body", which did not deliberately nudge subjects towards adopting a 3rdPP or 1stPP. Terms such as 3rdPP or 1stPP were avoided. For correlations of all dependent variables in each conditions, see the supplementary material.

Figure 4: A participant wearing an HMD and multiple tracking devices. Unlike 3rdPP in traditional games, where the character is controlled using a controller and button presses, the player controls the character by moving their body. We used a Bokken-style wooden sword as a tool to highlight the differences in perspectives (1stPP vs. 3rdPP).

Table 1: The two factors investigated in the study: 1) perspective (1stPP,3rdPP); 2) size and scaling of the camera and therefore participant (Normal, Diorama, Giant).

Scaling	1stPP	3rdPP
Normal	same size as skeletons (common in 1stPP VR)	same size as character and skeletons
Diorama	floor at hip level of user, small skeletons	floor at hip level of user, small character and skeletons (common in 3rdPP VR, e.g., Moss)
Giant	floor at foot level of user, small skeletons	floor at foot level of user, small character and skeletons

3.5 Participants

The study was carried out with a sample size of $n = 24$; 9 male and 15 female. Their ages ranged from 20 to 37 ($M = 25$, $SD = 3.41$). All participants reported to have normal or corrected to normal vision. The study was approved by the local ethics committee. None of the participants reported increased levels of motions sickness (all ratings < 10).

4 RESULTS

In this section, we report on our analysis of the results of the study (see Table 2).

4.1 Perception of perspective

To investigate whether there is a continuum of perceived perspectives within the VR scene we asked subjects to indicate on a visual analogue scale where between 1stPP and 3rdPP they would place their perception of the scene. To test the distribution of perspective ratings for multi-modality, i.e. to determine if there were more than two perspectives, we tested the data against the assumption of bimodality. In other words, we wanted to know if the data obtained was sourced from a distribution with two peaks or more. First, we instigated how the perceived perspective was distributed between the 1stPP and 3rdPP conditions. To that end, we conducted an excess mass test following the procedure by Ameijeiras-Alonso et al. [1]. This procedure is based on kernel smoothing and enables comparing whether a Null-model, a bimodal distribution in our case, results in excessive mass on the smoothed distribution of values. In our case, the test allowed us to determine if the observed distribution was significantly different from a bi-modal distribution. We found a strong indication of multi-modality in the excess mass test, $Excessmass = 0.077, p < .001$. This shows that the perception of the presented perspectives is perceived as neither uni-modal nor bi-modal (see Figure 5). There are clearly identifiable peaks other than the most dominant ones on the right and on the left side, which stand for 1stPP and 3rdPP respectively, on the smoothed distribution (Figure 8, top). At the bottom of Figure 5, we present the individual ratings in the six conditions for every participant on the lines. Here, it is evident that participants chose points not only on the right- or leftmost side of the scale, but also perceived the VR as being in-between 1stPP and 3rdPP.

We computed a repeated-measures analysis of variance (rmANOVA, Type III, $\alpha = .05$) with *size* and *perspective* on the aligned rank-transformed data using ARTool [23], due to a violation of normality. We found a significant effect of *perspective*, $F(1, 115) = 115.80$, $p < .001$, but no main-effect of *size*, $F(2, 115) = 0.53$, $p = .588$ or an effect of the *perspective* × *size* interaction, $F(1, 115) = 0.36$, $p = .700$. Thus, camera heights had no effect on the perspective scores.

4.2 Presence

We computed a rmANOVA with *size* and *perspective* as within-subjects factors (Shapiro-Wilk test: $W = .98, p = .123$; Mauchly Test: $M_{size} = 0.88$, $p_{size} = 0.25$; $M_{perspective} = 0.95$, $p_{perspective} = 0.06$). We found that the scores for the IPQ questionnaire showed a significant drop in the sense of presence in 3rdPP (see Figure 6). The main effect of *perspective* was statistically significant $F(1, 23) = 72.44, p < .001, \eta^2 = .76$. The main effect of *size* was not statistically significant $F(2, 46) = 0.96, p = .390$. There was no interaction effect between *perspective* and *size*, $F(2, 46) = 2.94$, $p = .063$.

4.3 Embodiment

The feeling of agency (see Figure 8), body ownership (see Figure 9) and self-location were significantly affected by the used perspective. In a rmANOVA (Shapiro-Wilk test: $W = .93$, $p < .01$; violation of the normality-assumption) on the rank-aligned data, for Agency, a main effect of *perspective* was statistically significant ($F(1, 115) = 140.32$, $p < .001$). The main effect of *size* was not significant $F(2, 115) = 0.37, p = .688$, nor was there any interaction effect, $F(2, 115) = 2.00, p = .14$.

In terms of body ownership, the Shapiro-Wilk test was significant, indicating a violation of normality. We, again, computed a rmANOVA on the rank-transformed data. The main effect of *perspective* was statistically significant, $(1, 115) = 26.14, p < .001)$. The main effect of *size* was not significant, $F(2, 115) = 1.37$, $p = .257$. and there was no interaction effect, $F(2, 115) = 1.83, p = .165$.

For self-location (see Figure 10, the Shapiro-Wilk test was significant, indicating a violation of normality. We, again, computed a rmANOVA on the rank-transformed data. The main effect of perspective was statistically significant, $(1, 115) = 6.84, p = .01)$. The main effect of size was not significant, $F(2, 115) = 0.12, p = .884$, and there was no interaction effect, $F(2, 115) = 0.3, p = .741$.

4.4 Games Experience Questionnaire

We found a significant drop in the ratings of the games experience questionnaire and all its subscales in relation to the used perspective of 3rdPP (see Figure 7; Shapiro-Wilk test: $W = .99, p = .52$). The main effect of *perspective* was statistically significant and large, $F(1, 23) = 4.44$, $p < .046$, $\eta^2 = .16$). The main effect of *size* was not significant, $F(2, 46) = 1.26, p = .293$. The interaction between *perspective* and *size* was significant and small, $F(2, 46) = 3.22$, $p = .049$, $\eta^2 = .12$. None of the Bonferroni-corrected post-hoc t-tests reached significance, all $p > .067$.

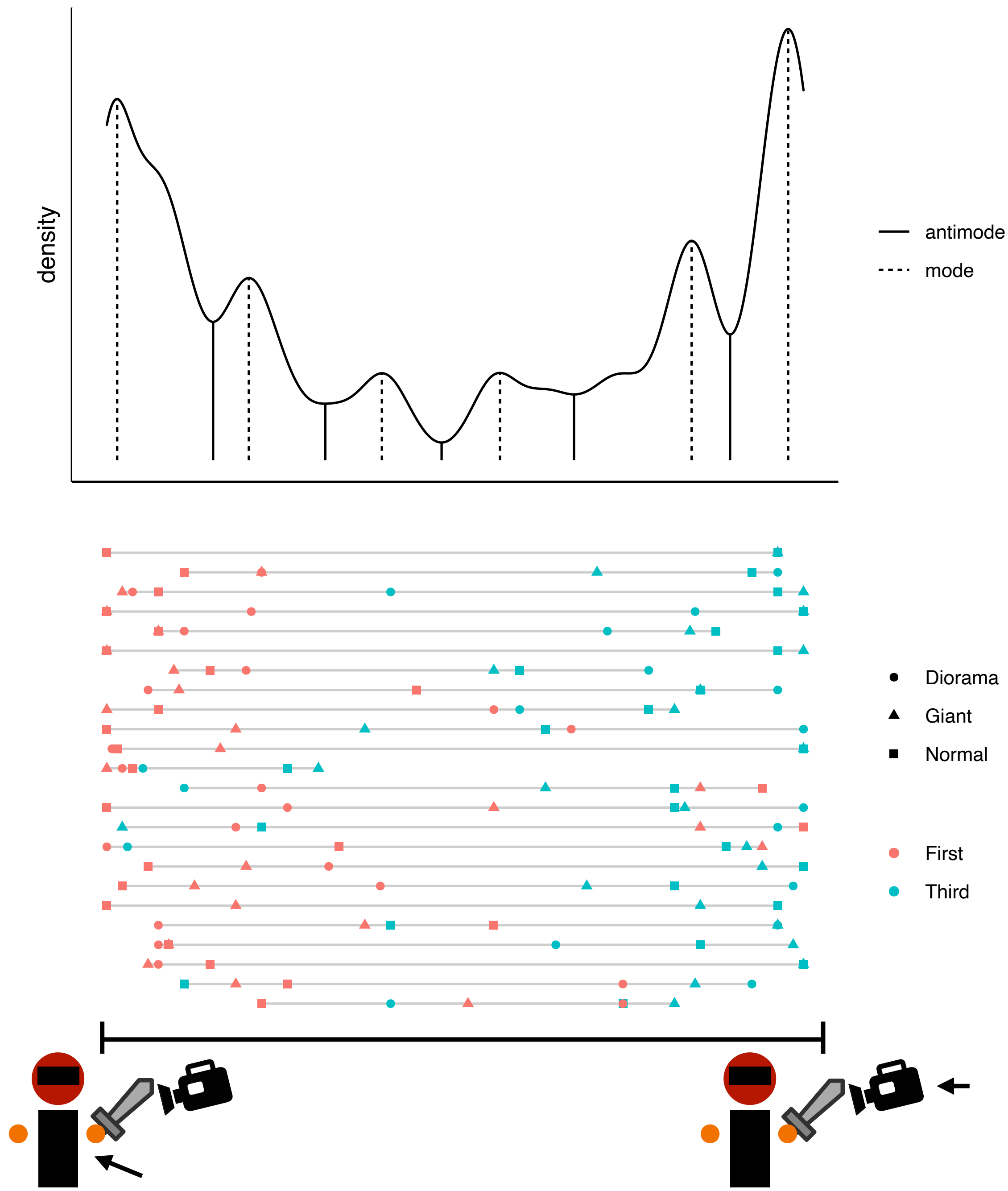


Figure 5: Distribution of scores for "I felt that I was in the body of the..." on a visual analogue scale. Statistical analysis indicates that the distribution is not bi-modal. This shows that the perception of the presented perspectives is perceived as neither uni-modal nor bi-modal.

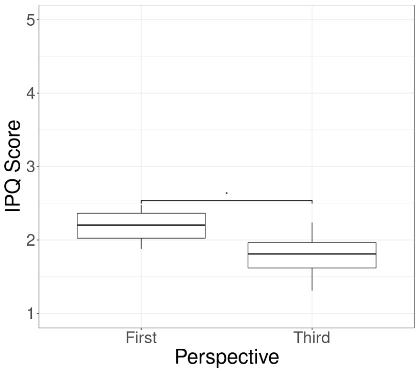


Figure 6: IPQ scores for the two perspective. There was a significant main effect between the conditions, $p < .001$

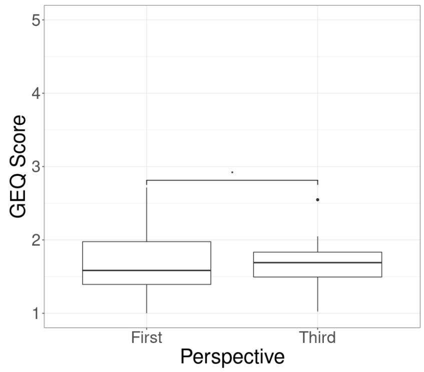


Figure 7: Game Experience Questionnaire scores for the VR scene played in 3rdPPand 1stPP.

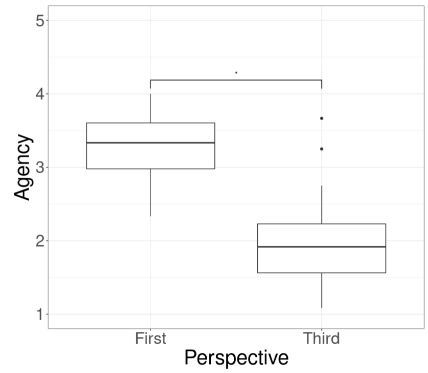


Figure 8: Reported ratings of perceived agency in 3rdPPand 1stPP. There was a significant difference between the conditions.

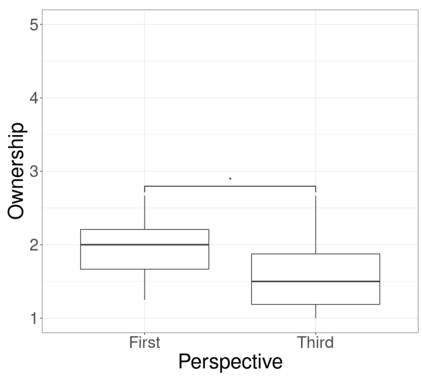


Figure 9: Perceived body ownership in the two perspectives.There was a significant difference between the conditions.

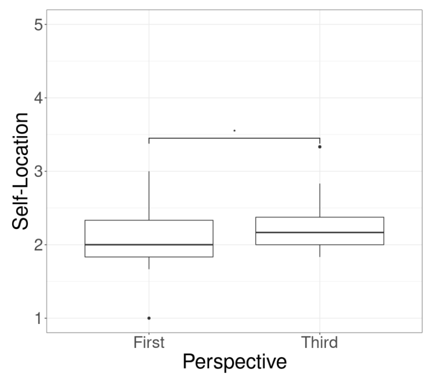


Figure 10: Perceived self-location in the two perspectives. There was a significant difference between the conditions.

Table 2: ANOVA models for all dependent variables with Shapiro-Wilk test. If the Shapiro-Wilk test was significant, indicating deviation from normality, we used the ARTool ANOVA with a mixed model specification. This procedure uses rank-alignment to specify ANOVA-like models on non-normal data.

	perspective			**size**			**perspective × size**			**Shapiro-Wilk**	
Dependent Variable	df	F	p	df	F	p	df	F	p	W	p
Perspective ratings	1,115	115.80	<.001	2,115	0.53	.59	2,115	0.36	.70	0.85	<.001
IPQ Score	1,23	72.44	<.001	2, 46	0.96	390	2, 46	2.94	.063	0.99	.123
Agency	1,115	140.32	<.001	2,115	0.37	.688	2,115	2.00	.141	0.94	<.001
Body ownership	1,115	26.14	<.001	2,115	1.37	.257	2,115	1.83	.165	0.98	.028
Self-Location	1,115	6.84	.010	2,115	0.12	.884	2,115	0.30	.741	0.81	<.001
GEQ-score	1, 23	4.44	.046	2, 46	1.26	.293	2, 46	3.22	.049	0.99	.516

5 DISCUSSION

The VR perspective continuum not only sheds light on how we understand perspective in VR scenes, but it can also be used to open new possibilities for the design of future VR experiences.

Our results showed that scenes that were perceived as camera in body (1stPP) received a high agency rating, while scenes with the camera outside of the body (3rdPP) had a general lower agency rating. This implies that manipulating perspective may be an effective way to change the perceived agency of the user in the VR scene. Designers can apply this technique when they want to increase immersion or want to decrease feelings of control. This way, VR scenes can benefit from perspective shifts similarly to desktop games, e.g., to allow for detached gaming experiences when seeing the character from above.

We did not find significant evidence that size or camera setup is a factor on the perspective continuum. As our experiment was designed to sample points on the continuum of 1stP- and 3rdP perspective, we have not granularly sampled for the size factor. However, while we did not find any strong effects, the camera setup could have small but significant effects on the perceived perspective and affect the perception of player in a different setup or task. Further investigation of camera setups as a factor is needed, as the chosen camera setup could not be distinct enough or other factors such as the control scheme, character design, or exposure could influence the perceived perspective.

We found a significant drop in reported presence for 3rdPP. This could be potentially caused by "taking away" the user's hands and sword, which was not in line with what users had known from previous VR experiences where actionable items are represented at arm's length. While hands and sword could be seen as an extension of the 3rdPP character, this is rare design choice in VR. Therefore, the drop in presence could be caused by legacy bias, as no changes were made to the presented scene other than avatar-related elements. We identify two implications of this result. First, a shift to 3rdPP could be used to remind the user that they are not in the physical world, for example to signal that they are leaving the play area. Second, it remains a challenge for future research in VR to determine if, and possibly how, perspective shifts can be made possible without a drop in presence.

Further, our analysis showed that participants in the 3rdPP condition perceived a lower level of embodiment. While different design decisions or longer periods of exposition could be taken to increase the level of embodiment (even in 3rdPP), a drop in embodiment can also be used as an intentional design choice, e.g. to reduce embodiment in order to limit negative feelings. Therefore, the use of 3rdPP can be a design decision to intentionally lower agency, similarly to manipulating body ownership. This property can be potentially used in scenarios where VR is applied in the health domain (e.g., exposure therapy sessions).

All in all, we recognise that there is a cost to shifting perspectives in VR in terms of presence and embodiment. It is a challenge for future designers to decide whether the cost outweighs the benefit of providing a more varied experience through shifting perspectives. Therefore, future research should further investigate if ratings such as sense of presence, agency, and ownership can be increased by the introduction of design elements that strengthen the connection to the 3rdPP character [3]. Moreover, there is a need to explore longer exposures to 3rdPP in VR to determine the role of legacy bias in its perception.

5.1 The VR Perspective Continuum

Our results show that users demonstrate diversity in how they perceive perspective in VR. As the observed difference is not a bi-model distribution, the concept of perspective in VR is not composed of two discrete notions—1stPP and 3rdPP. Instead some users perceive VR experiences as a blend of the two perspectives. We therefore argue for the existence of a *perspective continuum for VR*. Rather than terms such as 1stPP and 3rdPP, that are commonly used in traditional games, it is beneficial to conceptualise perspective in VR as a continuous dimension.

The perspective continuum is a chance for the design of experiences and games unique to VR. This is not limited to offering a better overview by using of a 3rdPP camera position, or an increased movement range of the character compared to the movement in the tracking space by movement scaling, but can also be utilised for story telling by switching perspectives [4], while also being able to create 3rdPP memories in the form of an observer-like position [22]. Different points on the continuum can also be utilised for exposure therapy or "easy modes" for horror games, as scenes designed in 3rdPP received lower ratings in terms of presence, agency and ownership.

While these results are potentially affected by a legacy bias towards 1stPP, the introduction and altering of design aspects (such as control scheme, avatar/character representation), could affect and improve these ratings. Changes of such design elements could potentially allow designers to adjust the users' (self) perception between 1stPP and 3rdPP. In order to effectively use the continuum, its properties and effect, we need a vocabulary.

5.2 Terminology

1stPP and 3rdPP are terms used in traditional computer games that describe the position of the virtual camera and therefore how the scene is perceived. However, these concepts cannot be directly transferred to VR as personal experience and interpretation of the scene impact these perspectives and definitions. As an alternative, we propose the use of terms in relation to the character (in-character, out-of-character) and to the design element (perspective, control scheme, etc.):

- *Within-Character view* — The viewpoint is located inside the character (traditional 1stPP);
- *Out-of-Character view* — The viewpoint is located outside the character (traditional 3rdPP);
- *Within-Character embodiment* — The scene and character are perceived as the own body and being the character;
- *Out-of-Character embodiment* — The scene is experienced as being a form of puppeteer controlling the character;
- *Within-Character control* — Character mirrors movement tracked via head and hand positions;

[3]This is in line with our correlation analysis of all dependent variables that highlights that the enjoyment of the gaming experience for 1stPPand 3rdPPVR experiences can markedly differ.

- *Out-of-Character control* — Character is controlled via button presses on a gamepad.

Using these terms when discussing perspective in VR focuses on the design of the experience and reduces possible differences in how users perceive the scene. For example, one player could perceive a game with a camera perspective that is located outside of the character as 1stPP, feeling as if they were looking at a diorama and being a puppeteer. Another person could perceive the same situation as 3rdPP—feeling as if "being the character" while looking at it from the outside, similar to an out-of-body experience. In our terminology, the design case could be unambiguously specified as *Out-of-Character view*.

We note that one could argue that VR experiences are always perceived from a 1stPP. Even when looking at a character that one controls, the technology of VR HMD and head tracking gives the chance to "look into a virtual world" while being fully immersed. When using a 3rdPP design in VR, some users will therefore perceive themselves standing in front of a diorama or dollhouse while controlling a remote character, while others will have an out-of-body experience.

5.3 Using the VR Perspective Continuum

The perspective continuum and terminology we suggested can help to more accurately describe design aspects of VR experiences and games, especially when exploring designs that are inspired by traditional 3rdPP. However, we are especially interested in exploring the use of active shifts along the perspective continuum. Utilising changing perception in unique ways that are only possible in VR. Such shifts could offer a wide variety of use cases for artistic expression, storytelling, game design, and therapy. Below, we provide examples of how the perspective continuum could be utilised by VR designers and investigated by VR researchers.

Our novel approach on perspectives in VR offers several practical implications for the development and design of future VR games. Shifting the player's perception between in-character and out-of-character could be used to gradually increase or decrease relation with character where necessary. Throughout a game's story, the connection to the character could be enhanced by switching from controlling the character via button presses (*Out-of-Character control*) to hand- and head-movements (*Within-Character control*).

Out-of-Character view in VR may create immersive experiences and allow for direct control while keeping an overview or switching between characters while keeping high levels of presence. For example, in a strategy game, the player could control an army of uniform characters while issuing commands (*Out-of-Character control*) but also control a certain singular unit with direct control (*Within-Character control*) from a 3rd-Person perspective (*Out-of-Character view*) where necessary. Therefore creating seamless transitions between being invested in special characters and keeping an overview of the field.

Out-of-Character view VR may be used to reduce adverse feelings when facing threatening situations in games. When viewed through the eyes of the character an in-game event potentially inducing fear or creepiness [54] may result in less negative emotion when viewed from a distance. Even if the character is controlled from a *Within-Character control* scheme. Such a perspective shift could also be utilised for accessibility. If a VR game or experience is too intense for the player, e.g., in the case of horror games, a switch to an out-of-character experience could adjust the intensity of the experience, preventing any negative effects of play in VR [17]. This is not only limited to switching from *Within-Character view* to *Out-of-Character view*, but could also be achieved by other means such as going from a direct *Within-Character control* to a *Out-of-Character control* or by making the player feel less connected to the character by changing the design of the player character [44]. This way, perspective shifts can be used similarly to the arachnophobia mode in the survival game Grounded[4], where the details of the enemy spider get gradually reduced to make them a mere abstract representation of a real spider (removing details, removing eyes, removing limbs, display spider as textureless sphere).

Further, shifting the perception along the perspective continuum could be used to modify the perception of risk situations when evaluating risk-taking in VR [6]. Future studies could investigate the influence of perspective on risk-taking in VR for that purpose. When using VR scenes in exposure therapy sessions, decreasing embodiment could be an effective strategy to gradually increase exposure to an anxiety related stimulus [15]. Our work suggests that exposure experiences should begin in *Out-of-Character embodiment* and gradually move to *Within-Character embodiment*. Furthermore, perspective shifts can potentially shift one's perception of oneself. Slater et al. [48] used a form of self-dialogue for counseling where the user takes over roles of two VR characters during a dialogue, where VR was used to reassemble a distancing paradigm during which participants try to resolve personal issues by adopting a 3rdPP.

5.4 Limitations

While our study demonstrated a perspective continuum and followed a rigorous research process, we recognise that it is subject to certain limitations. Here, we address the limitations to discuss the generalisation of the concept of a perspective continuum. First, we took inspiration for our study from video game concepts and design elements in the form of 1stPP and 3rdPP. Therefore, we explored the use of 1stPP and 3rdPP in a sword fighting game. While the concept of a perspective continuum offers new design possibilities for VR games the potential effects and use cases for other scenarios, such as therapy (e.g., depersonalisation), training (e.g., increasing situational awareness), or other experiences need to be explored and discussed.

Second, while we found evidence that the perceived perspectives are not uni- or bimodal more points must be sampled in different scenarios between the extremes. A first step to further develop such a scale is to understand the influencing design factors of the VR scene and the weighting between them. While we investigated traditional perspectives (1stPP vs. 3rdPP) and multiple camera setups (Normal, Diorama, Giant), we mainly found significant results for the perspectives. However, camera setups with more distinct

[4]https://news.xbox.com/en-us/2020/07/27/grounded-arachnophobia-mode-details/ - Last accessed: Jan 2022

values could lead to a significant effect on the shift along the continuum. This would allow to finely quantify how changes in perceived perspective occur to find factors that make VR experiences more personal (i.e., towards 1stPP) or detached (i.e., towards3rdPP).

Third, our experimental system used simple tracking and character rendering. To limit the number of variables we did not investigate the effect of design factors such as the level of fidelity, design of the character model, or control schemes (handheld controller vs. body tracking). We hypothesise that if visualised hands were introduced to the observer position to any 3rdPP condition of our setup, this could shift the ratings along the continuum towards the traditional 1stPP. This, in turn, would result in perceiving the scene as a traditional 1stPP VR experiences where another character mimics one's movement. On the other hand, the use of a haptic prop such as the wooden sword can potentially nudge the ratings towards a stronger feeling of embodiment in the 3rdPP character as a form of tool embodiment, similar to the rubber hand illusion [2].

We also used a simplified and abstract character model to create a neutral experience for all participants and make it easier to connect to the character. Such a design choice may improve the perception of 3rdPP. In line with this, the design of the character model can have an impact on self-perception and therefore could also impact the perspective continuum [46]. This aligns with the overall low ratings of agency in 3rdPP that could be the result of the simplified character(e.g. not fully rigged or animated character). While, a legacy effect and proprioception can lead to a high agency in 1stPP, the simplified and not fully rigged and animated character could lead to lower agency in 3rdPP. Nonetheless, as we sampled multiple points in 1stPPand 3rdPPthis could only change absolute levels but not differences between conditions on perspective ratings. Future studies should investigate the impact of animation and rigging high fidelity on agency and embodiment in both 1stPP and 3rdPP designs. Thus, as of yet, it is unclear what design factors have an influence on the perspective continuum and if one design factors outweighs the effect of the others.

Fourth, in our study, we did not vary the time of exposure between participants or condition, therefore the effect of time of exposure on perception and ratings are yet to be investigated. We assume that a legacy effect during 1stPP conditions probably makes it easier to participants to get acclimated, while longer exposure to 3rdPP could be needed in order to increase the embodiment and familiarity with the character. Thus, long-term user studies are needed to fully grasp the perception of perspectives and the potential adaptation of perspective within VR.

One of the technical design limitations is the combination of camera and character control. Looking backward in 3rdPP conditions leads to losing track of the character. To avoid this and to keep the focus towards the character we spawned the skeletons in front of the camera. As we combined *Out-of-Character view* with *Within-Character control* (movement tracking and head rotation), the camera/observer position cannot be moved independently from the character. A solution could be to allow to relocate the camera by walking while locking the character placement by a button press. However, we avoided this to keep the setup simple and not alienate or confuse novice VR users. Solutions for this issue that are used place in traditional desktop 3rdPP games are not directly transferable to VR. Locking the camera rotation or automatically focusing the character would not only lead to a loss of agency, as the user is unable to freely rotate their head and therefore camera, but would lead to motion sickness as the user's movement would not align with the perceived visual motion.

Overall, to strengthen the concept of the perspective continuum in VR, future studies should systematically vary contexts, characters, control mechanics and extend exposure time.

6 CONCLUSION

1stPP and 3rdPP are common design elements in traditional games. VR developers, however, often limit perspectives used in VR to 1stPP. While some 3rdPP VR experiences exist, they can often be described as the player taking over an observer perspective and controlling a character remotely, such as when controlling a radio-controlled car. We studied the user experience of perspectives in VR and compared 3rdPPand 1stPP. In our study, we found that the participants' perception towards the used perspective was not bi-modal, and thus their experiences could not be attributed to only First or Third-person view. We proposed the VR perspective continuum as an alternative concept to discrete perspectives and suggested an accompanying terminology that will help researchers and designers to consider using Third-person View in VR applications as a viable design alternative. We also found that ratings of presence, agency, and embodiment were lower in 3rdPP. Yet, our work also shows benefits of 3rdPP and its potential for fostering novel interactive concepts. Thus, the perspective continuum is a resource for building varied VR environments. We hope that our work inspires further research into perspective perception in VR and supports designing richer, more diverse VR experiences with regard to viewpoints.

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