Of Portals and Orbs: An Evaluation of Scene Transition Techniques for Virtual Reality

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Figure 1: Four of the six transition techniques as seen by users while transitioning. Dissolve: The next scene is faded in continuously until it is completely visible. Orb: The user grabs the orb and moves it towards her head, in order to transition to the next scene. Portal: The user walks through the portal into the next scene. Transformation: A rift to the next scene opens up and spreads around the user.

ABSTRACT

A lot of virtual reality (VR) experiences require switching between different environments or scenes. To achieve a plausible and perspicuous transition between those scenes, transition techniques can be used. These techniques visualize the change and should support continuity in storytelling and a high degree of presence while respecting the interactive nature of VR. We implemented six different transition techniques. Three of them are inspired by techniques which are used in movies since decades: Cut, Fade, and Dissolve. Furthermore, we added three techniques that leverage the peculiarities of VR: Portal, Orb, and Transformation. The techniques were compared in a user study regarding presence, continuity, usability, and preference. The results showed significant differences for all variables. In general, Orb and Portal received highest ratings.

CCS CONCEPTS

• Computing methodologies → Virtual reality; • Human-centered computing → Virtual reality.

KEYWORDS

Virtual Reality, Portals, Scene Transition

1 INTRODUCTION

Transitions are used in different media like film, video games, or VR experiences as a segue between scenes or levels. "Just as writers use transitional phrases (however, moreover, in fact) to bridge ideas, filmmakers use transitional devices to bridge scenes" [15]. Additionally, transitions can be used as stylistic devices to facilitate storytelling. They are used in order to denote changes in space and time, to change pacing and mood of a narrative, or even to create narrative meaning in itself [2, 14, 15]. Continuity editing refers to a collection of rules and conventions in film editing, which help the audience follow the narrative of a film (see Section 2). Every transition has fundamental properties regarding continuity. They either make the scenes feel connected to each other or they help setting them apart.

In context of VR, the transitions’ stylistic properties are of importance, and especially, their effects on presence. In short,
presence is the user’s subjective feeling of “being there” inside the virtual environment and is one of the most important properties of VR, that distinguishes it from other forms of media [41, 42] (see Section 2). Thus, presence supporting transitions will benefit most use cases of VR.

Today’s immersive VR systems (e.g. HTC Vive [8]) allow for new ways of interaction, which are not possible in film or traditional video games. Users can navigate through virtual environments by means of real walking and manipulate objects naturally using diegetic controller input. This opens up new opportunities for designing novel interactive transition techniques specifically for VR.

In this paper, six different transition techniques for VR (3 traditional, 3 VR specific) are evaluated in regard to different properties: Presence as it is of high importance in the context of VR, Continuity as it is a central stylistic property of transitions, as well as Usability and user preference to allow for further comparison and assessment. The goal is to enable informed design decisions on transition techniques for VR.

2 RELATED WORK

In this section, presence and continuity are described and put into scientific context. Furthermore, an overview of related work on the topic of transitions in movies and VR is given.

Presence and Continuity

Presence is central to the definition of VR [40, 42]. It is described as the subjective feeling of “being there” [41] in the virtual environment. High presence can lead to a VR experience causing the same emotions and reactions as a real experience [31, 39]. Thus, presence is of high importance for treating anxiety disorders and phobias with VR therapy [32, 34]. In VR entertainment, high presence is often a goal in itself [3, 35] and enriches storytelling [29]. Factors for presence are numerous and can be categorized in the following way [35]: Vividness, interactivity, and user characteristics.

Vividness or immersion refers to the technical aspects of VR systems [3, 42]. Properties such as framerate, field of view, or spatial sound have influence on the perceived presence [1, 19, 30].

Interactivity “refers to the degree to which users of a medium can influence the form or content of the mediated environment” [42]. Navigating one’s own body inside a virtual environment is the “central interaction” [33] followed by manipulating objects and influencing agents [33]. Welch et al. showed that interactivity in general can increase presence [51]. Slater et al. identified that whole body movements have a positive effect on presence [38].

User characteristics are individual differences between users. They cause different levels of presence for different users [35]. Level of concentration, prior experience with VR, expectations of the VR experience, or proneness for motion sickness are possible causes [6]. Involvement as a psychological state and the “willing suspension of disbelief” [42] are further important factors regarding user characteristics [42, 52].

In film, continuity means a visually unbroken, coherent narrative style. A scene should be experienced as a whole without noticeable breaks, even though it is comprised of multiple separate shots [2]. In order to achieve this, several rules and conventions have been established under the term “continuity editing”. One example is the 180-degree rule which states that the audience should always stay on one side of the action [2]; all shots have to be located on the same spatial half, in order to maintain continuity. Transitions can either be used to preserve a sense of continuity even during location or time changes, or to actively break continuity in order to indicate the end of a narrative thread [15].

Event Segmentation Theory is the basis of psychological research regarding continuity [36]. It describes perceptive and cognitive processes “by which people parse a continuous stream of activity into meaningful events” [55] and is closely tied to the prediction of ongoing events [23, 53]. Segmentations occur when features of the environment change (unexpectedly) [53]. Changes in environment are, for example, intentions and goals of actors (conceptual) or color, sound and, especially, movements (sensory, physical) [23, 54]. Magliano & Zacks showed that continuity editing supports the segmentation of meaningful events and, therefore, bridges “breaks in low-level visual continuity, and even breaks in continuity of spatial and temporal location” [25]. Serrano et al. showed that traditional continuity editing also preserves continuity in 360°-VR-movies [36].

Transitions

Film - Scientific research on transitions and film editing in general already began in the 1920s. For example, Lew Kuleschow showed in several experiments (the "Kuleschow Effect" and other) that film editing can drastically change the meaning of a scene [2].

While, in the 1930s, noncut transitions (e.g. dissolve and fade) were used in 99% of scene changes, contemporary film only uses these transitions in 13% of cases [13, 14]. Even though noncuts aid the audience in segmenting a scene [13], viewing habits changed to the point that today the simple cut is by far the most often used transition technique for changing scenes [14, 21]. Exceptions are scene changes that are more difficult to understand. For example, scenes where time changes but not the location, or special scene changes, e.g., transitions into and out of dream sequences. In these cases, contemporary film still uses noncut transitions to aid the audience [2, 13, 14].

In the field, different properties regarding the assistance or break of continuity are attributed to transitions. Certain
transitions are recommended for specific situations; e.g., dissolves for depicting passages of time or wipes for changes of location [14, 15, 21]. There seems to be a lack of scientific studies examining transitions regarding this aspect.

**VR** - Bruder et al. used portals to navigate inside of 3D architectural models in VR in order to present the user with a persistent and continuous world and to “minimize breaks in the user’s sense of ‘feeling present’” [5]. Freitag et al. used portals as a reorientation technique in order to overcome great distances by means of real walking [16]. In [22], Photoportal are used as references for collaboration inside a CAVE environment. These 2D and 3D world-in-miniature representations of a scene could be used as a gateway by moving ones head into the Photoportal.

Moghadam & Ragan examined transition techniques regarding motion sickness and spatial orientation. The considered transitions were instant positional changes, fade-outs, and animated camera movements. The preliminary results showed that the tested techniques can cause orientation problems. It is presumed that faster transitions are preferred by experienced users [27]. Oberdörfer et al. analyzed the effects of transition techniques on presence, illusion of virtual body ownership (IVBO), efficiency, and naturalness. The considered transitions were fade-out, 180°-turn-around of the user while the scene change occurs, and virtual head-mounted display (HMD). The virtual HMD transition worked in such a way that the user put on a virtual HMD displaying the next scene, while being inside a virtual environment. The techniques were categorized by their interaction type (physical vs. artificial) and motion type (continuous vs. non-continuous). Results showed that none of the transition techniques had an impact on presence or IVBO [28]. Men et al. analyzed the impact of four transitions on presence. The transitions were divided into more and less visible transitions. Results showed that salient transitions break presence, while less visible transitions preserve presence [26]. Coelho et al. built upon the taxonomy of [26] and categorized transitions for the CAVE by their naturalness. Natural transitions, in comparison to supernatural and traditional transitions, were rated higher and lead to a higher feeling of presence [7].

3 TRANSITION TECHNIQUES

In the course of this work, six transition techniques were implemented. Three traditional film transitions, i.e., cut, fade, and dissolve, were adapted for VR. Orb, Portal, and Transformation are three novel techniques specifically designed for VR. All transitions maintain head and controller tracking at all times; the user is always in control of the camera movements. Fade, Dissolve and Transformation each take 1.3 seconds to finish.

**Cut** - The scenes are changed in between two frames, resulting in an instant change for the user. Cut was chosen as a baseline condition. It is the simplest and fastest transition possible.

**Fade** - Over a short amount of time, the complete vision is faded away to black. Then, the process is reversed, but now the user is inside the next scene. In film, a "fade denotes demarcation" [15] and is used to separate scenes [21]. Fade was chosen because it is used in a lot of VR applications (e.g. Beat Saber [17], Skyrim VR [44], Fallout 4 VR [43]) and related work [26–28], yet it is a traditional transition and does not use new features of VR.

**Dissolve** - The next scene is faded in continuously until it is completely visible. At the same time, the current scene becomes less visible. Figure 1 shows the mid-transition view. Both scenes can be seen at the same time, the user can still move and look around without restrictions. In film, a dissolve denotes continuity because it can "form a bridge between disparate times and places" [21]. Dissolve was chosen because it is the most commonly used noncut transition in film [14] but it is not very present in VR applications.

**Transformation** - At the beginning of the transition, an oval rift to the next scene opens up in the user’s field of vision (see Figure 1). The rift spreads all around the user, until the first scene is completely gone and the user is inside the next scene. Transformation was chosen, because it makes use of VR specific features to some extent (spatial transition around the user), but still is very similar to the traditional techniques as it is not interactive and could be interpreted as a variation of the iris out transition. The VR application NVIDIA VR Funhouse [45] served as an inspiration for the spatial transition.

**Portal** - At the beginning of the transition, an oval portal opens up in front of the user. The user can look through the portal into the next scene (see Figure 1). From the side, the portal appears to be flat, and from the back, it is invisible. In order to execute the transition, the user walks through the portal into the next scene. When the user has arrived in the next scene, the portal closes behind her. Walking through the portal does not have to be a continuous action. For example the user can stop halfway and examine the border between both scenes. It is also possible to go back into the previous scene, as long as the user does not completely walk through the portal. Portal was chosen because it requires whole body movement and provides a seamless transition. The video game Portal [49] served as main inspiration.

**Orb** - At the beginning of the transition, an orb appears in the environment. Trough the orb, the user can look into the next scene. The orb can be grabbed with a controller by moving it close to the orb and holding down a button. In this state, the orb can be dragged by moving the controller (see Figure 1). If the user releases the button, the orb will stay at it’s new location and the user can examine the next scene from a new angle. One can also walk around the orb.
and change the viewing angle this way. If the user wants to transition to the next scene, the orb has to be grabbed and moved towards the user’s head. Then, the orb wraps around the head, seamlessly transitioning the user to the next scene. Orb was chosen because it makes use of the new possibilities that VR offers in terms of interaction (body movement, diegetic controller input) and because a lot of VR applications use variations of this technique (e.g. Google Earth VR [18], The Lab [50], Accounting [12]). The very similar virtual HMD metaphor was previously analyzed in [28]. The VR game Budget Cuts [9] served as main inspiration for this transition technique.

4 EXPERIMENT

Six transition techniques (Cut, Fade, Dissolve, Transformation, Orb, Portal) were compared in a user study with regard to presence, continuity, usability and user preference. According to the findings in Section 2, we expect Orb and Portal to be rated higher than the other techniques in regard to presence. Both techniques require a high degree of interaction. Regarding continuity, Orb and Portal are also be expected to be superior to the other techniques. Both techniques allow for a view into the next scene, making the environment change more predictable. Following the attributions in the field of film, Dissolve should be rated higher than Fade regarding continuity.

Environments

The participants used each transition technique to cycle through five different environments. The environments contrasted with each other in terms of theme, coloring, and size in order to let the participants test the techniques in as many different scenarios as possible. Two familiarization environments were created in which the participants learned how to use the different techniques. In terms of visuals, these were held very simple but contrasted with each other in color, so that the participants would focus on the techniques and could easily notice the effects of the transitions. All environments are depicted in figure 2.

Measures

Presence was measured using the Slater-Usoh-Steed Presence Questionnaire [48]. Additionally two questions from [26] were tested, because they focus on the used technique and it’s effects on presence (see table 1). For these two questions the presence was calculated as the mean on a scale from 1 to 7. The questionnaires were filled out each time the participant finished using the current technique. Continuity was calculated as the mean (scale: 1 to 7) of the three continuity questions from table 1. The questions were posed each time the participant finished using the current technique.

Usability was measured using the System Usability Scale [4] each time the participant finished using the current technique.

Preference was measured using the questions from table 1. The rating was calculated as the mean (scale: 1 to 10) of the first question, which was posed each time the participant finished using the current technique. The other two questions were part of the post questionnaire at the end of the experiment.

Qualitative feedback was acquired using the questions from table 1 each time the participant finished using the current technique.

Procedure

The study design of [7] served as a reference. The study was conducted in a within subject design, every participant used all six techniques. To minimize order effects, the order of techniques was pseudo-randomised using latin squares. The experiment took between 40 and 60 minutes per participant to finish.

Start phase: The participants filled out a consent form and the pre-questionnaire concerning demographic data. Thereafter, the HMD was calibrated and the workings of the VR systems and the procedure of the experiment were explained to the participant.

Technique phases 1-6: This phase was repeated six times, once for every technique. The mechanics of the current technique were explained to the participant, and after that, the participant put on the HMD. The participant started inside one of the familiarization environments (see figure 2). There, the participant could walk around inside the tracking space and get accustomed to the technique and VR in general. The current technique could be used to switch between the two familiarization environments as often as the participant wanted, in order to get acquainted with the technique.

Then, the environment sequence was started. The participant had to use the current technique to switch through a sequence of the first five environments in figure 2. A sequence always began and ended with the start/end environment, the rest of the environments each appeared once in random order. The participant could only travel through the sequence in forward direction (each environment was visited once) but was allowed to explore each environment from inside the tracking space as long as she wanted. When the participant decided to leave, she used the current transition technique to switch to the next environment.

When the sequence was finished, the participant took off the HMD and filled out the questionnaires regarding presence, continuity, usability and preference. When the participant was ready, the next technique phase was started.
Figure 2: All environments the participant visited during the experiment. The start/end environment and the two familiarization environments are depicted in the bottom row.

Table 1: Non-standard questionnaires

<table>
<thead>
<tr>
<th>Variable</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence</td>
<td>The transition technique reminded me that I was in a virtual world.</td>
</tr>
<tr>
<td>Presence</td>
<td>The transition technique made the virtual world become less real.</td>
</tr>
<tr>
<td>Continuity</td>
<td>Travelling through the different environments felt like a continuous process.</td>
</tr>
<tr>
<td>Continuity</td>
<td>The transition technique made the different environments feel connected with each other.</td>
</tr>
<tr>
<td>Continuity</td>
<td>The transition technique interrupted my experience in the environments.</td>
</tr>
<tr>
<td>Preference</td>
<td>In general, how do you rate the transition technique?</td>
</tr>
<tr>
<td>Preference</td>
<td>Which transition technique did you like the most?</td>
</tr>
<tr>
<td>Preference</td>
<td>Which transition technique did you like least?</td>
</tr>
<tr>
<td>Feedback</td>
<td>Did particular environments (indoor, outdoor, urban, etc...) have influence on how you perceived the transition technique, or on how you felt while using the transition technique?</td>
</tr>
<tr>
<td>Feedback</td>
<td>Additional comments: What did you like/dislike about the transition technique</td>
</tr>
</tbody>
</table>

End phase: After the participant finished all 6 technique phases, one last questionnaire had to be filled out. It contained more questions concerning demographic data and general preference.

Participants
A total of 22 subjects participated in the experiment (8 female, 14 male). The participants were between 18 and 68 years old, with a mean age of 26.45 years. Most participants were students, who were rewarded with student experiment credits. All participants had normal or corrected-to-normal vision. 18 Participants reported to have already used a VR-Headset before. Experience with 3D video games was evenly distributed between very experienced and very inexperienced participants.

Implementation
The experiment system and transition techniques were developed using Unity [47] version 2018.2.15f1. For general VR functionality and controller input, SteamVR Plugin [10] version 2.0.1 was used. For the environments, multiple asset packs were used [11, 20, 24, 37, 46]. The HTC Vive Pro HMD (resolution: 1440x1600 per eye, refresh rate: 90Hz)[8] was powered by a Geforce GTX 1080Ti, 16GB of ram and an Intel Core i7-4930K processor @ 3.40GHz. The participants could move within a 3x3m tracking space.

Cut, Fade, Dissolve, and Transformation were triggered by the participants by pressing a button on the controller. Portal was triggered automatically. As soon as the old portal was closed, a new portal was opened up on the opposite side inside the tracking space. Orb was triggered automatically. As soon as the last transition was finished, a new orb was spawned in the center of the tracking space.

5 RESULTS
SUS Presence - Figure 3 shows the results of the SUS-Presence-Questionnaire. A Shapiro-Wilk test suggests that the assumption of normal distribution is not violated. A repeated measures ANOVA found a significant main effect for the 5% significance level with F(5,105)=8.034, p=.001. A Tukey test
for the 5% significance level found significant differences in presence for the following pairs: Orb - Cut (p=.019), Orb - Transformation (p=.045), Portal - Cut (p=.03). Orb was rated significantly higher than Cut and Transformation; Portal was rated significantly higher than Cut.

**Technique related presence** - Figure 3 shows the results of the two further questions explicitly regarding the used technique and it’s impact on presence. A Shapiro-Wilk test showed that the data is not normally distributed. A Friedman test found a significant main effect for the 5% significance level with \( \chi^2=34.083, \text{df}=5, p<.001 \). Table 2 shows the significant results of a Wilcoxon test for the 5% significance level. Orb and Portal were each rated significantly higher than Cut, Fade, Dissolve and Transformation; Dissolve was rated significantly higher than Transformation.

**Continuity** - Figure 4 shows the results for the questions concerning continuity. A Shapiro-Wilk test suggests that the data is not normally distributed. A Friedman test found a significant main effect for the 5% significance level with \( \chi^2=67.195, \text{df}=5, p<.001 \). Table 3 shows the significant results of a Wilcoxon test for the 5% significance level. Orb and Portal were each rated significantly higher than Cut, Fade, Dissolve and Transformation; Dissolve was rated significantly higher than Transformation.

**Usability** - Figure 5 shows the results of the System Usability Scale. A Shapiro-Wilk test suggests that the data is
not normally distributed. A Friedman test found a significant main effect for the 5% significance level with $\chi^2=13.234$, df=5, $p=.021$. A Wilcoxon test for the 5% significance level found significant differences in usability for the following pairs: Cut - Transformation ($p=.02$), Fade - Transformation ($p=.016$), and Orb - Transformation ($p=.006$). Transformation was rated significantly lower than Cut, Fade and Orb.

Figure 5: System Usability Scale - mean scores, standard deviations and individual scores.

Rating - 15 (68.2%) participants liked Orb the most, followed by Portal (5, 22.7%) and Dissolve (2, 9.1%). Cut was liked the least by 12 (54.5%) participants, followed by Transformation (5, 22.7%), Fade (3, 13.6%), Portal (1, 4.5%) and Dissolve (1, 4.5%).

Figure 6 shows the techniques’ ratings on a scale from 1 to 10. A Shapiro-Wilk test suggests that the data is not normally distributed. A Friedman test found a significant main effect for the 5% significance level with $\chi^2=50.656$, df=5, $p<.001$. Table 4 shows the significant results of a Wilcoxon test for the 5% significance level. Orb was rated significantly higher than all other techniques; Portal was rated significantly higher than Cut, Fade, Dissolve and Transformation; Dissolve was rated significantly higher than Cut.

Table 4: User rating - significant Wilcoxon test results.

<table>
<thead>
<tr>
<th></th>
<th>Orb (p&lt;.001)</th>
<th>Portal (p=.035)</th>
<th>Dissolve (p=.003)</th>
<th>Transf. (p&lt;.001)</th>
<th>Portal (p=.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut</td>
<td>Cut (p&lt;.001)</td>
<td></td>
<td>Cut (p=.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fade</td>
<td>Fade (p=.001)</td>
<td></td>
<td>Dissolve (p=.003)</td>
<td>Transf. (p&lt;.001)</td>
<td></td>
</tr>
<tr>
<td>Dissolve</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Transf.</td>
<td></td>
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</table>

Figure 6: User rating - mean scores, standard deviations and individual scores.

Qualitative Feedback

The participants were not obliged to give feedback. For every technique, there were around 10 comments, so the feedback should be perceived with caution. However, the comments yielded a lot of additional insights.

Cut - Most comments regarded the high speed and "abrupt" nature of the transition, which was rated negatively most of the time. Multiple participants stated, that travelling through the different environments felt more like a "slideshow" than a continuous experience. Transitions from small indoor environments to large outdoor environments were described as "extreme" or "overwhelming" by some participants. The "very easy" use and the unobstructed view on the surrounding environment were noted as positives.

Fade - The transitions between environments appeared more as a "slideshow" with different pictures and less as a continuous journey. The briefly blacked out field of vision was perceived as unpleasant by one participant.

Dissolve - Transitions from large outdoor environments to small indoor environments were described as "uncomfortable", "confusing", and "abrupt" by some participants. This was because in this sequence, walls and objects from the second environment were faded in very closely to the participants. In contrast, transitions from indoor to outdoor were stated as "pleasant". Apart from that, the transition was perceived as "smooth" and "not abrupt".

Transformation - For some, the animation was "distracting" and felt "unnatural", for others it felt like "waking up from a dream", which was reinforced by transitioning from outdoor to indoor environments.

Portal - In many comments it was stated that the portal took up too much space and obstructed the view on the rest
of the scene. On the other hand, this allowed for a "good insight into the next environment". Walking into the next scene and staying at the crossing of two scenes was perceived as "witty" and "amusing". For some participants the oval bottom of the portal caused the feeling of stubbing one’s foot. The invisible backside of the portal and the opening/closing animation were perceived as distracting sometimes. Multiple participants came up with the idea to integrate the portal into the environment (e.g. on a wall or hidden behind a door).

**Orb** - The technique was described as "witty" and "fascinating". The view into the next scene was rated positively and resulted in a less sudden transition. The interaction and "firm control" over the transition were rated positively. The always visible nature of the orb and the fact that the orb had to be located again inside each environment were the stated negative aspects of the technique.

### 6 Discussion

The properties of six different transition techniques were examined in regard to presence, continuity, usability, and preference of the users. The techniques Orb and Portal use the interactive and visual possibilities of VR and scored the highest in regard to presence, continuity, and user preference, and equally as high as the other techniques regarding usability.

In order to sustain high presence and continuity over a change of scenes, the user should be able to interact with the transition. Furthermore, the user should be able to take a look into the next scene, before executing the transition. The used animations and effects should be unobtrusive. The transition should enable a continuous visual flow and should not be abrupt. If the application does not allow for interactive transitions, Dissolve is the best alternative of the tested techniques.

In order to break presence and continuity, fast and sudden transitions, e.g. Cut, can be used to surprise the user. The noticeable animation of Transformation draws further attention to the virtuality of the experience. It should be kept in mind, that these transition techniques were not popular with most participants and were rated negatively.

In the following, the partial results are interpreted and discussed in more detail.

**Presence** - The SUS presence results show that Orb and Portal were rated significantly higher than Cut; additionally, Orb was rated significantly higher than Transformation. The additional questions explicitly regarding the techniques' impact on presence provide more definite results: Orb and Portal were rated significantly higher than all other techniques. The results can be explained by the high degree of interactivity which is offered by Orb and Portal. Portal requires real walking and Orb requires arm movement to manipulate the orb. Looking at the scene through the orb from different angles also caused whole body movements in a lot of participants. Dissolve’s significantly higher rating than Transformation can be explained by nature of the transition animation. Dissolve’s animation was perceived as "smooth", while Transformation’s animation was perceived as "distracting" and "unnatural". The low rating of Cut is probably caused by the "very abrupt" transition and the often stated "slideshow effect" which is explicitly queried in the SUS-Presence-Questionnaire.

**Continuity** - The examined continuity refers to location changes only, one of the seven possible narrative shifts (combinations of location, time and character changes) [13]. Orb and Portal were rated significantly higher than all other transitions. This can be explained by the view into the next scene, which is only offered by Orb and Portal. The view into the next scene makes it possible for the user to become familiar with the next scene before the transition is executed. Furthermore, the user’s position inside the next scene can be anticipated, or, in case of the Orb transition, determined exactly. According to Event Segmentation Theory, this reduces the probability of segmentation, because the scene change is less unexpected [53]. With Dissolve, the next scene is faded in slowly and not instantaneously as is the case with Cut, thus, making the change less unexpected. In contrast to Fade, Dissolve never breaks the visual flow. Thus, the established rules for transition continuity in film, can be confirmed for fade and dissolve for VR context (see section 3).

**Usability** - The results show, that the higher complexity and higher required degree of interaction of Orb and Portal have no negative impact on usability. This could change in usage scenarios where users have to execute transitions very often over a long period of time. Then, the required whole body movements could lead to fatigue phenomena. Transformation was rated significantly lower than Cut, Fade, and Orb. This is surprising, as there is no difference between Transformation, Cut, and Fade in terms of interaction. The result could be attributed to the transition animation. For a more accurate interpretation, further investigation is needed.

**Ratings** - Orb was rated significantly higher than all other techniques. This is likely caused by the often stated high fun factor and the other positive properties regarding presence, continuity, and usability. The significantly lower rating of Portal (but still significantly higher than Cut, Fade, Dissolve and Transformation) is probably due to the disadvantage of the required space and smaller aspects of the implementation (portal shape, invisible backside, opening/closing animation). Dissolve’s significantly higher rating than Cut is probably due to the transition animation which was generally perceived as more pleasing.
7 CONCLUSION AND FUTURE WORK

A user study was conducted to evaluate six different transition techniques for virtual reality in regard to presence, continuity, usability, and user preference. Three traditional techniques (Cut, Fade, Dissolve) and three novel interactive VR specific techniques (Transformation, Portal, Orb) were tested.

The results are in line with previous theoretical findings. A high degree of interaction results in a higher feeling of presence. Predictable and less abrupt transitions have a higher continuity rating, especially transitions that allow for a preview into the next scene. The transition techniques Orb and Portal score significantly higher than the other techniques regarding presence, continuity, and user preference and do not fall behind other techniques regarding usability. Thus, Orb and Portal should be used as transition techniques in situations where high presence, continuity, and user acceptance are desired.

In this paper, the focus was on continuity in regard to location changes. There was no focus on a narrative meaning, which would have high impact on event segmentation and continuity. Future studies should evaluate the effects of transition techniques in regard to other narrative shifts (combinations of location, time, and character changes) in different application contexts (e.g. games, storytelling context).

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