CREATING NEW MUSEUM EXPERIENCES FOR VIRTUAL REALITY

Wolfgang Hürst, Bibi de Boer, Wouter Florijn, Xhi Jia Tan

Department for Information & Computing Sciences, Utrecht University, The Netherlands
huerst@uu.nl

ABSTRACT

We present a pilot study investigating if and how we can create more engaging and improved user experiences in a virtual reality (VR) museum context. In particular, we used the so-called inpainting and artistic style algorithms to present different visualizations of paintings in a VR museum implementation. An experiment with 34 participants demonstrated the potential of this approach, especially among people usually not very interested in such art. It also highlighted possible issues to consider and directions for future research.

Index Terms— VR museum, inpaiting, artistic style algorithm, new VR museum experiences, user engagement

1. INTRODUCTION

Digitizing artwork such as paintings does not only enable new ways of access, for example via mobile devices; it also allows us to modify, process, or extend historical art pieces in ways that might be beneficial for the observer. Appealing, new types of access via personal devices could make people more interested in art, create more engaging ways to experience it, teach about particular aspects of a painting, and so on. There are many ways to digitally modify or extend art work in creative ways that might provide opportunities for new, innovative, and beneficial usage. For example, inpainting [1] automatically analyzes the content of a painting in order to extend it beyond its borders (Fig. 1). Gatys et al. [2] present an algorithm that identifies the artistic style of a painting and applies it to random photographs (Fig. 2). Others have created full 3D worlds based on paintings that can interactively be explored by the users [3].

The 3D world described in the latter example is accessed via virtual reality (VR) head mounted displays, thus not only presenting the otherwise "flat" data in 3D but also creating a strong level of immersion. In general, VR offers tremendous potential for the access and usage of art, especially in context of virtual museums. Many approaches exist to recreate museums in VR (cf. [4], for example), also providing the benefit of being able to visit a museum at a remote place without having to travel there.

Fig. 1. Example for inpainting[1]. The original image (marked by the rectangle) is automatically extended beyond its borders.

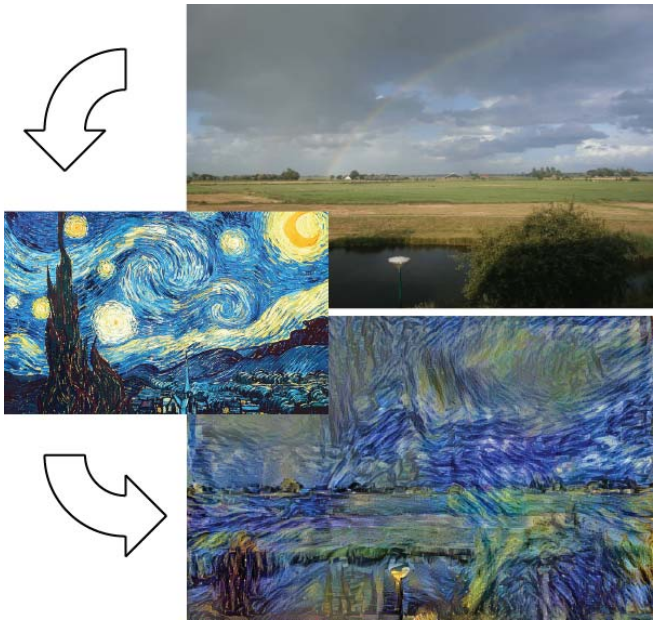

Fig. 2. Example for the artistic style algorithm. The style of a painting is analyzed and applied to a photo (top) to automatically create a version of the photo in the artistic style of the painting.

[1] Vincent Van Gogh's painting *Starry Night*, which is in the public domain, was used for all illustrations in this paper: https://commons.wikimedia.org/wiki/File:Van_Gogh_-Starry_Night_-_Google_Art_Project.jpg

Our research is more focused on using virtual reality and techniques for modification or extension of art in order to create new VR museum experiences and provide different ways to interact with art pieces, in this case paintings. The opportunities are endless. Imagine visual effects such as the ones evaluated by the IllumiRoom project in context of video games [5]; for example, a painting of a winter landscape made more immersive by snowflakes falling in the (virtual) space around you. The algorithm from [2] could be used for educational purposes, for example, to teach people about particular characteristics of artistic styles.

In this paper, we investigate if and how inpainting and the artistic style algorithm can be used in a VR museum setting in order to create different user experiences. An initial study with 34 participants addresses their potential with respect to user engagement and subjective experience. After specifying the context of our work (Section 2), we describe implementation and experimental design (Section 3), present the pilot study results, and discuss them with respect to a potential usage in VR and regular museum contexts (Section 4) before concluding (Section 5).

2. FOCUS OF THIS RESEARCH & RELATED WORK

Many approaches exist for the creation of VR museum experiences; see [3, 4, 6, 7], for example. Likewise, there are various concepts from art and other domains that suggest potential usage in this context; cf. the examples mentioned in the introduction [1, 2, 5]. In this pilot study, we investigate the technique of inpainting and the artistic style algorithm from [1, 2] illustrated in Figures 1 and 2. Our work does not address the actual technique used to create these contents, but investigates their application in a concrete use case. To the best of our knowledge, there has been no evaluation of these algorithms with respect to their potential for improving museum experiences so far, neither in real nor in virtual museum contexts.

If or how such techniques can be used beneficially also depends on the actual usage goal. Most existing work evaluates VR museum installations with respect to user experience or enjoyment. For example, Sylaiou et al. [8] verify if an increased level of presence in a VR museum adds to the perceived enjoyment. Karoulis et al. [9] present a usability study with respect to interaction and interface design in a VR museum setting. Other, less explored aspects include the goal to attract more people to museums (both real and virtual installations) and make them more interested in art; an important aspect especially with today's technology focused younger generations. User engagement, enjoyment, and experience are important issues in this context. In our pilot study, we therefore focus on the latter using informal questions and interview techniques plus a questionnaire based on the structure of the well-known PANAS construct [10] that can be used to measure affect or emotion (cf. next section). Other aspects to study include the effect of new technologies or visualization approaches on education, learning, and memorization. For example, Henkel [11] presents a study suggesting that taking pictures when visiting a museum can have a negative effect on memorizing artifacts of the exhibition. Although this is not the major focus of our pilot study, it inspired us to include a small memory test at the end in order to investigate any potential impact of the used approaches.

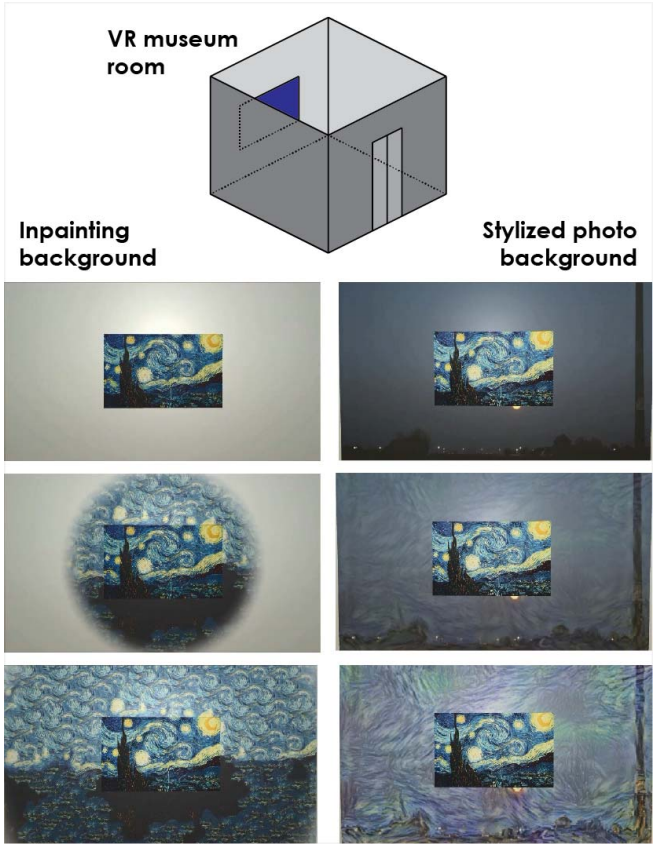

Fig. 3. Back walls in the virtual museum room: extended painting (left) using inpainting (with animation from top to bottom) and stylized photo (right) morphing from original to stylized.

3. IMPLEMENTATION & EXPERIMENT DESIGN

Commonly, paintings are displayed on a plain wall. The basic idea of this research was to investigate the potential of a representation that takes advantage of the algorithms discussed in the preceding sections. In particular, we were interested in figuring out if we can increase interest in art and improve user engagement and experience (a) by visualizing an "extended painting" calculated with the inpainting algorithm, and (b) by putting a photo related to the content of the painting on the back wall, which then slowly morphs to the painting's style using the artistic style algorithm. Our major aim was to test if the added animations show some potential for the creation of VR museum apps. Yet, if successful, our results could provide useful information for the design of exhibitions in real

museums as well, since the basic setup is applicable in this context, too (e.g., via a projection on the back wall). We reflect on related discussions with the participants in the concluding section.

For this, we implemented a prototype setup with a small virtual museum featuring different rooms (Fig. 3). Each room shows one painting at the opposite side of the door. After some initial experimentation with various options (such as a permanent still image and various morphing or extension animations for the two cases), we decided to use the following two implementations: For the artistic style approach, a content-related photo was shown on the whole background wall and then slowly morphed into the stylized version calculated with the algorithm, followed by the reverse morphing process back to the original photo. This sequence was played in an endless loop. For inpainting, people entering the room initially saw the original painting on a plain wall. Then the extension via inpainting was fading in with an expanding circular motion (cf. Fig. 3, bottom left). This animation was only shown once, but could be replayed by pressing a button on the floor. There was no actual motion of the user in the implementation but people were seated on a rotating chair during the experiment and thus could explore the room by rotating. Looking at the door on the opposite side of the painting for a short amount of time made them exit the room.

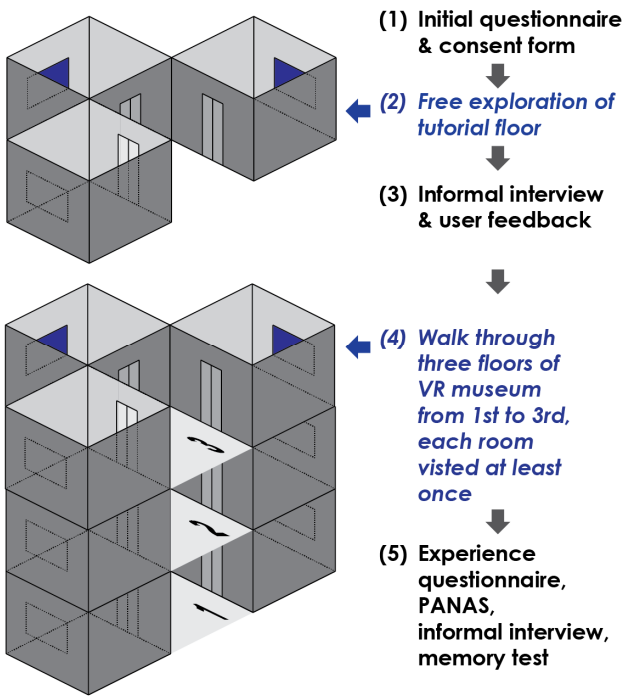

Fig. 4. Experiment design (overview). Steps in italic were done in VR with subjects wearing a head mounted display.

For the actual test, we designed a small museum with three rooms in each floor (cf. illustration in Fig. 4, top left). Each floor featured one room with a stylized photo in the background, one with inpainting-style extension, and one with a standard setup where the original painting was hanging on a plain wall. Icons on the doors indicated what effect was used in which room. The back wall on the fourth room in the center showed an escalator door (not illustrated in Fig. 4) enabling people to exit the floor and proceed to the next one. The implementation was done using a VR case for smartphones and a Sony Xperiz Z5 premium smartphone (5.5-inch screen, 2160x3840 pixels resolution, although the actual VR application ran at 1080 pixels) as head-mounted VR display.

Tests were done in a neutral lab environment with subjects seated on a rotating chair. At the beginning, participants had to sign a consent form and provide some context information (gender, age, interest in VR and art/paintings, etc.). Fig. 4 illustrates the general procedure of a test session with one participant, which took approximately 40 minutes to one hour per subject, depending on the length of the informal interview and resulting discussion. Each session started with a tutorial-style first round where subjects could roam a single floor of the museum (Fig. 4, top left). They were encouraged to talk to the person performing the test and make comments about the experience, which were noted by a second, neutral person in the room. After exploring all rooms, subjects removed the VR headset and had a short informal discussion with the testing person about their experience, what they liked or disliked, etc. This was followed by a walk through a small museum setup featuring three floors with four rooms (Fig. 4, bottom left). Again, three rooms contained paintings with different effects like in the tutorial floor. The mapping of effect to room differed per floor and between subjects based on a Latin square design. There was no given order in which the rooms had to be visited, and subjects could enter a room multiple times. Yet, they had to go into each room at least once in order to activate the elevator to the next floor. Participants were asked to explore the museum on their own and there was no interaction with the testing person during this round. After exiting the last floor, subjects had to fill in two questionnaires, had another informal discussion with the testing person, which was followed by a concluding short memory test, also in the form of a questionnaire. The used questionnaires as well as characteristics of the 34 participants are described in relation to the results in the next section.

4. RESULTS & DISCUSSION

The 34 participants were students from our local computer science program, aged between 20 and 29 (average 23.15 years) with eight females and 26 males. Because they are all students of a technical discipline, we did not expect much difference between genders and thus did not enforce a

gender balance. We purposely restricted our experiment to a group with such a homogeneous age and educational background, because being able to make younger, technology-focused people more interested in art is one of the potential benefits we expect from our approach. Tests with other demographics would go beyond the focus of this pilot study but are an important aspect to consider in future work.

As expected, people from the subject group did not frequent museums very often (18 with zero, five with one, seven with two and four with three museum visits in the last year). Most of them expressed an average interest in art and paintings: 2.82 and 2.5, respectively on a five point Likert scale with 1 = *not interested* and 5 = *very interested*. Only one person gave the highest rating (5) for both (interest in art and paintings). Interest in paintings was rated with 4 by three more subjects. From all participants, only two had experienced a VR museum app before.

In the following, we describe the results from the questionnaires and related comments from the informal interviews and discussions. Additional data was logged during the experiments; such as time spent in each room, order in which rooms were accessed, and how often a particular room was visited. All this data was analyzed but did not reveal any interesting or relevant observations.

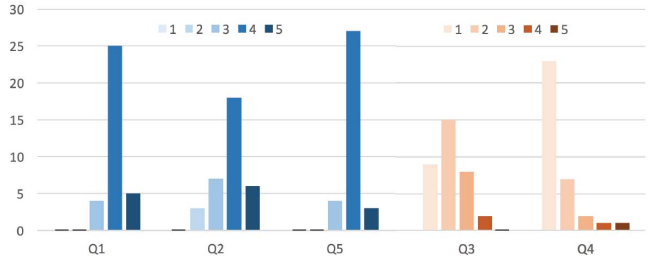

Fig. 5. User experience questionnaire results.

Experience. The first questionnaire users had to fill out after the final visit of the VR museum addressed their experience. In particular, subjects had to give ratings on a five point Likert scale from 1 (= *completely disagree*) to 5 (= *completely agree*) for the following statements:

- Q1: *I liked the experience*.
- Q2: *The experience was relaxing*.
- Q5: *I enjoyed the experience*.
- Q3: *I was bored during the experience*.
- Q4: *I don't want to experience this ever again*.

The question number indicates the order in which the statements were presented to the subjects. To better analyze them, we grouped them here by positive ones (Q1, Q2, Q5; higher rating is better) and negative ones (Q3, Q4; lower rating is better). Fig. 5 illustrates the results (three positive ones on the left, two negative ones on the right).

It can clearly be seen that the positive questions are generally rated rather high with averages of 4.03, 3.79, and 3.97 for questions Q1, Q2, Q5, respectively. Most subjects also did not agree with the two negative statements, as expressed by the low averages of 2.09 and 1.53 for Q3 and Q4, respectively. While we have to consider the rather informal character of a pilot study like this one, we were still quite surprised about these positive results. A "wow effect" and "newness factor" certainly exists here as well, but given the strong technology background of the test subjects, we expect them to have a lesser impact than this is commonly the case in such settings. Despite this background and the fact that most participants had at least seen some VR applications before, many were impressed by the results of the used algorithms and the whole VR museum setup.

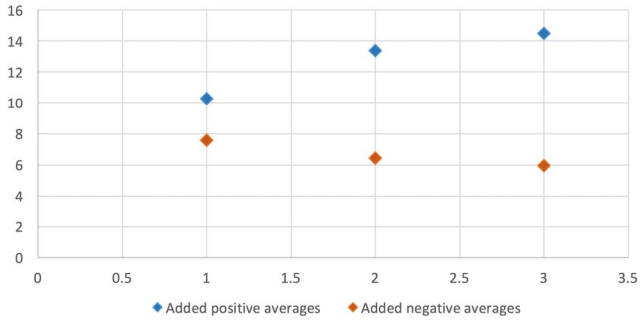

Fig. 6. User engagement / state (added scores).

Engagement. To measure user engagement, we took inspiration from the PANAS construct. In this setup, users are asked to rate ten positive and ten negative words describing a possible feeling or state from 1 (*very slightly or not at all*) to 2 (*a little*) to 3 (*moderate*) to 4 (*quite a bit*) to 5 (*extremely*). Scores for each word are then averaged over all subjects and summed up for the ten positive and ten negative words resulting in a mean positive and a mean negative affective score; a value between 0 and 50. While PANAS can be used to measure user engagement, we felt that the respective words (e.g., *guilty, hostile, ashamed, proud, alert*) did not match our use case. Thus we decided to use the following words instead:

- Positive: *amazed, joyful, at ease, enthusiastic*
- Negative: *sleepy, irritated, bored, distressed*

Mean affective scores are calculated as in the PANAS case but because we took only four instead of ten words, resulting scores are between 0 and 20 with higher values expressing a stronger positive and negative state, respectively. Cumulated positive and negative ratings (sum of averages of all positive and negative words) are illustrated in Fig. 6. Results for the individual scores (averaged over all subjects) can be found in Fig. 7 and 8 for positive and negative words, respectively.

We can observe a clear trend with people giving higher positive and lower negative scores in cases where additional effects are shown, with slightly higher ones for inpainting

compared to the stylized photos. This latter difference is too small though to draw reliable conclusions. We discuss possible reasons for this slight preference for inpainting below in relation to the participants' comments in the informal interviews and discussions.

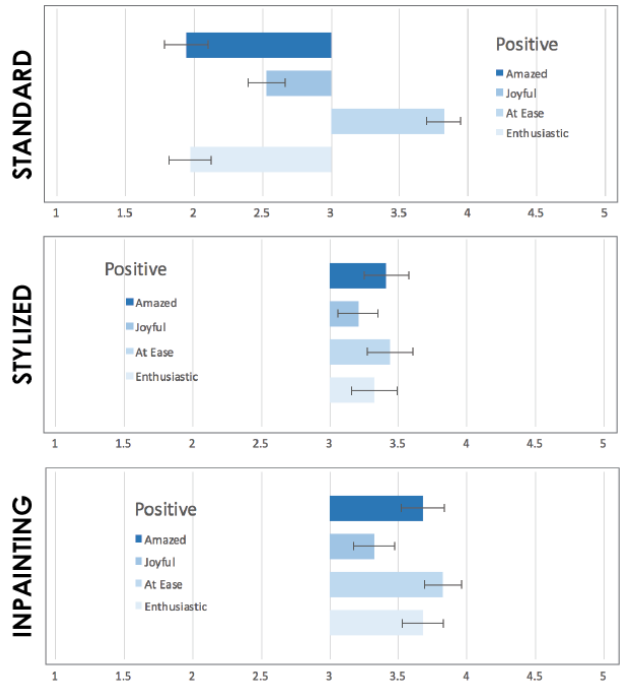

Fig. 7. User engagement / state (individual results; positive).

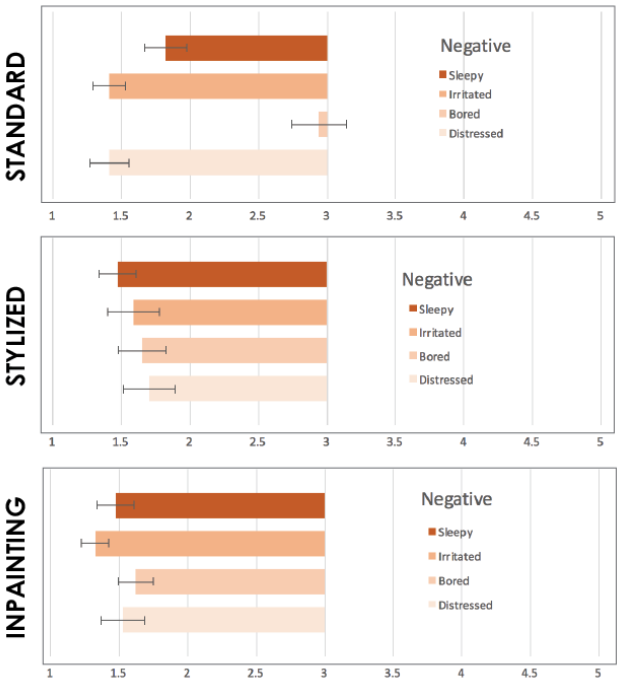

Fig. 8. User engagement / state (individual results; negative).

Memory effect. Motivated by the work presented in [11], which suggests that the usage of technology in a museum context might have a negative impact on how well people remember what they saw, we concluded the test sessions with a small memory tests. Each subject was presented a questionnaire with six questions. Each question showed a set of four paintings and subjects had to mark which of those (if any) they have seen in the museum. Some sets did not contain any painting from the VR museum, most contained one, and some contained two. We analyzed the answers by the subjects with respect to correctly labeled ones, missed ones, and false positives (paintings marked as in the museum although they were not) considering the related effect used for the particular paintings. No trend could be identified between the different effects. This is positive, since we assumed that the additions of inpainting and stylized photos could have a distracting effect. It should be noted though that our setup was not a formal procedure as in [11]. Hence, further research to confirm this initial trend is needed.

Qualitative statements. In their subjective statements during the discussions and informal interviews, participants generally confirmed the results gathered via the questionnaires, and provided further insight and ideas. Most people were very positive about the added effects, some even questioning the usefulness of a VR museum without them. Several people mentioned that without effects they do not see a reason why to wear a bulky VR headset instead of just looking at the paintings on a regular computer screen. They often mentioned that the plain, standard room does not take advantage of the possibilities that VR offers. Such statements are surprising and interesting, since both effects were displayed on the flat back wall, and thus could easily be added to paintings on a normal computer screen, too. It appears that seeing them in VR had an additional effect on people, such as better immersion or an increased feeling of presence – an issue certainly worth exploring further in future work.

The slight preference of inpainting versus the artistic style effect was also reflected in some comments of the subjects. Reasons included that the content was seen more interesting and related to the actual painting for inpainting, while the different photos used in the stylized case could also be distracting. Likewise, the constant changes due to the endless morphing loop were sometimes less appreciated and also experienced as distracting by a few users.

Despite this slightly more negative attitude towards stylized backgrounds, people generally appreciated the effects and said that they would encourage them more to download VR apps. Given the strong technology-background of the test group, this was kind of expected. What we did not expect though was that people who expressed having a general interest in art and paintings before the study also often mentioned that it would motivate them more to use VR apps for their phones. Yet, they also

generally agreed that it would neither be a replacement for a real museum visit nor would they appreciate related installations at a real museum, mostly because they would distract too much from the art there. A few people generally not interested in visiting museums mentioned however that if such installations would be present, it might be more likely that they visit them. However, the general trend seems to be that most subjects would highly prefer such effects in a VR museum, while similar installations in real museums might be less appreciated. People who usually do not visit museums mostly mentioned that they still would not do so, and people who frequently go to museums would consider it too distracting.

5. CONCLUSION & FUTURE WORK

The major goal of our pilot study was to investigate if digital enhancements of paintings might provide any benefit in a VR museum context. A minor goal was to further gain some insight if such effects could also be useful when applied as fixed installations in real museums. We targeted particularly younger, tech-savvy user groups, who are often less interested in traditional art such as paintings. Interesting issues were observed when comparing their comments to the few subjects who actually considered themselves as being more affiliated to this kind of art.

In general, both formal as well as qualitatively gathered feedback was very positive. While such an increase in appeal can generally be expected for a more technology-focused user group, the rather strong and clear trend is interesting and noteworthy. Most importantly though, this was also apparent among the subjects who expressed a general interest in such art. Most people concluded that the effects added to the experience, with many even questioning if a VR app without them would be useful. This consistent trend among both art and more technology focused participants was however only observed in a VR context. Integration of such effects into real museum installations was seen rather critical by participants with an art affiliation. Our pilot study thus showed a clear potential for applying such and other effects to paintings in VR museum installations. In addition, it provided some insight into important aspects of a concrete implementation, and identified interesting aspects worth further investigation.

First, our experiment obviously was only an initial step focusing on one particular type of digital enhancement in a very specific implementation. Variations of the latter, for example, via modifications of the algorithms or the representation of their results in different ways (e.g., different animations and visual shapes for inpainting, cf. Fig. 3) need to be further investigated. Likewise, there are countless other options to enhance or maybe even modify art work digitally that could provide similar benefits. In relation to that, one of the more art-affiliated subjects noted that artists might like the idea, too, and could even be interested in creating art works targeted for these kinds of automatic extensions and additions. Other ideas or issues raised in the discussions were the option to walk around and adding more interactivity to explore the art (e.g., by getting very close to it to examine little details). Finally, we observed that several subjects considered the extensions an essential aspect of VR although the same effects could easily be applied to a painting shown on a regular, flat computer display. This may suggest that they had an impact on issues such as immersion and the feeling of presence, which are very important aspects of VR experiences and thus worth further exploration.

6. REFERENCES

[1] Wolfram Blog, "Extending Van Gogh's Starry Night with Inpainting," http://blog.wolfram.com/2014/12/01/extending-van-goghs-starry-night-with-inpainting/ [last access: May 2016]

[2] Gatys, Leon A., Alexander S. Ecker, and Matthias Bethge, "A neural algorithm of artistic style," *arXiv preprint arXiv:1508.06576,* 2015.

[3] The Night Café – An immersive tribute to Vincent van Gogh, http://vrjam.devpost.com/submissions/36821-the-night-cafe-an-immersive-tribute-to-vincent-van-gogh [last access: May 2016]

[4] Oculus Rift app "Museum of the future," https://share.oculus.com/app/museum-of-the-future [last access: May 2016]

[5] Brett R. Jones, Hrvoje Benko, Eyal Ofek, and Andrew D. Wilson, "IllumiRoom: peripheral projected illusions for interactive experiences," *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '13), 2013.

[6] Roussou, M., "Immersive interactive virtual reality in the museum," *Proc. of TiLE (Trends in Leisure Entertainment)*, 2001.

[7] Carrozzino, M. and Bergamasco, M., "Beyond virtual museums: Experiencing immersive virtual reality in real museums," *Journal of Cultural Heritage*, *11*(4), pp.452-458, 2010.

[8] Sylaiou, S., Mania, K., Karoulis, A. and White, M., "Exploring the relationship between presence and enjoyment in a virtual museum," *International journal of human-computer studies*, *68*(5), pp.243-253, 2010.

[9] Karoulis, A., Sylaiou, S. and White, M., "Usability evaluation of a virtual museum interface," *Informatica*, *17*(3), pp.363-380, 2006.

[10] Crawford, J.R. and Henry, J.D., "The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample," *British Journal of Clinical Psychology*, *43*(3), pp.245-265, 2004.

[11] Henkel, L.A., "Point-and-shoot memories: the influence of taking photos on memory for a museum tour," *Psychological science*, *25*(2), pp.396-402, 2014.