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ORIGINAL ARTICLE

VR in Nursing Facilities - A randomized controlled multicenter pilot study analyzing the changes in the state of mind of seniors in nursing facilities through the viewing of 360° videos

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Abstract

Context VR as an application to enhance well-being is sparsely researched in the elderly population. The aim of the pilot study was to analyze the effect of 360° videos of different categories on the state of mind of seniors in nursing facilities. Furthermore, for the implementation in everyday life, the usability of the system and the experience for seniors should be evaluated.

Methods The VR experience was used as a supplement to existing care services in three facilities on eight subjects. Mood state was assessed using the *Questionnaire for the Assessment of Happiness* before and after the intervention. Demographic data and technology acceptance were collected beforehand. After the intervention, subjects were interviewed about confounding factors and side effects, and nursing home staff were interviewed about the usability of the system and the organizational concept of implementation.

Results There was a positive effect on state of mind. Gender and spatial mobility turned out to be influencing factors. Categories containing people, animals and action achieved the highest increases in the state of mind. Interest in using technical devices correlated negatively with the change in mood state. None of the subjects found the VR goggles distracting or reported motion sickness. Very good usability was indicated by the employees.

Conclusion A very high willingness to use this technology was found among nursing staff and residents. The tendencies of the positive effect of 360° videos on the state of mind, as well as differentiation based on the mentioned characteristics gender and spatial mobility, should be verified by a larger sample to empirically validate the use of this technology to increase the quality of life.

Keywords Virtual Reality · motion sickness; happiness · technology acceptance · usability

Introduction

During the currently prevailing Corona pandemic and the accompanying psychological stress, researchers presented a VR application with 360° videos to improve well-being asa cost-effective and scientifically validated method for self-help at home (Riva et al. 2020). Residents of nursing homes belong to the highest risk group and are therefore especially protected against infection. But it is not only during the prevailing pandemic that they struggle with social isolation and loss of independence. Among the elderly population, this is particularly consequential and can promote the progression of chronic diseases as well as lead to depression and anxiety (Appel et al. 2020). Also, long periods without employment lead to chronic boredom and chronic low moods (Yeo et al. 2020; Cohen-Mansfield et al. 1992). Exposure to new experiences can be counteracting to this (Appel et al. 2020). In the prevention and treatment of mental and physical illnesses, virtual reality has already been in use since 1990 with high patient satisfaction and simple and safe handling (White et al. 2018). For example, virtual reality is becoming an increasingly popular alternative to traditional upper and lower limb rehabilitation (Iruthayarajah et al. 2016).

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In contrast to VR-based rehabilitation therapies, virtual reality for enhancing well-being in the elderly population has been sparsely researched. Many studies, which are examining the use of virtual reality to enhance mood or well-being, conducted their research exclusively on younger individuals. Presumably, due to the well-founded scientific findings on the positive effects of nature (Ulrich et al. 1991; Kaplan and Kaplan 1989; Wilson 1984), the majority of studies focused on virtual nature and its impact on people. There is a consensus among researchers that simulated natural environments are therapeutically valuable or can activate health-promoting mechanisms and improve emotional well-being. These offer an alternative, especially for populations for whom in vivo contact with nature is not possible (Browning et al. 2020b; McMahan and Estes 2015; Negrín et al. 2017; Yu et al. 2018; White et al. 2018). Appel and her colleagues were one of the few to conduct feasibility study with residents from nursing homes or ambulatory care facilities. They found a high acceptance of this technology and a high willingness to perform the intervention. They also found no side effects such as nausea, dizziness, anxiety, or interference with medical devices. Most subjects reported positive feedback, and 70% said they would like to experience virtual reality again (Appel et al. 2020). Rose and other researchers also evaluated the use of virtual reality on people suffering from dementia in an inpatient psychiatric care facility and examined the effects on well-being and behavior. They found an overall positive impact of VR on people with dementia. A significant improvement in pleasure and alertness from before to after exposure was noted. Again, no side effects such as anxiety, sadness, or anger were observed (Rose et al. 2019). Moyle and her colleagues also conclude that virtual reality forest has the potential to improve the quality of life of people with dementia. However, even though the application was generally perceived as positive, it showed higher levels of anxiety during the VR experience (Moyle et al. 2017). Overall, a mini-review of existing feasibility studies concludes that visually appealing scenes can increase well-being (D'Cunha et al. 2019).

The following work analyzes the effect of 360° videos, which are viewed by residents from several nursing homes using virtual reality (VR) goggles. The central research question is whether there is a change in the resident's state of mind and if this change is attributable to the intervention. Further, the influence of (socio-) demographic data and technology acceptance on the change in the state of mind of the nursing home residents will be investigated, as well as the effect of the different categories and the different lengths of the shown 360° videos. Furthermore, the study examined whether the effect lasts. This means whether the change in the subjects' state of mind who have already frequently viewed 360° videos is similar to that of those subjects who have not done so. Concerning the applicability of the system used for viewing 360° videos in everyday nursing care, the aim is to examine how the nursing staff copes with the operation of the system and how the experience can be further improved for the residents of the nursing facilities. Overall, this pilot study will develop and evaluate a concept and generate hypotheses that will be analyzed in subsequent studies with larger samples.

Methods

Due to the pandemic, the subject acquisition took place indirectly. To create two groups of equal size, subjects were assigned to the test or control group using block randomization. The intervention was compared to care as usual and thus the daily or entertainment program established in the institutions. In this context, the viewing of the 360° videos was not performed as a substitute, but as an addition to the usual routines of the individual residents. In the control group, the usual daily routine was supplemented only by the survey of the state of mind. As compensation, the subjects of the control group were also offered the viewing of a 360° video after the end of the study.

A trained employee from each nursing facility was responsible for the on-site implementation, who will be named as the person responsible for the on-site implementation in the following. All phases of data collection thus took place internally in each institution. The on-site implementation took place in one institution on 01/11/2020 and 01/12/2020 and the other two institutions on 01/18/2021 and 01/19/2021. The on-site implementers, who were not familiar with the operation of the system for the intervention, were instructed in its use. Two of the facilities were familiar with the handling of the 360° video playback system and one facility was instructed in its operation. To keep the conduct of the study as identical as possible at each of the facilities, a detailed experimental protocol was prepared and handed out, among other things. To ensure that this was adhered to, those responsible for implementation were required to complete and sign a checklist after each session. In addition to ensuring that the procedure was analogous to the experimental protocol, the checklists also served to double-check that the subject was the correct one and that the session was conducted by the schedule. Also, the respective checklist for a subject's intervention included the randomly assigned video. A head-mounted display (HMD) was chosen as the playback medium for the 360° videos. The Oculus Quest from the manufacturer Oculus VR was used as a so-called all-in-one headset. Ten 360° videos were provided by the company diginetmedia for this study. For the reasons just described interaction with virtual reality was not used. To address the issue

of distraction caused by the bulkiness of the HMD, subjects in the test group were asked after the intervention whether they found the VR goggles distracting. In summary, the technology used in this study is in the upper midfield. This is mainly due to the price, as the application should also be recommended for use in everyday care if the study results are positive.

The 360° videos were tagged with keywords (e.g. nature, action, relaxation) and thus categorized in advance. The 360° videos had different lengths since no study could be found that provides valid results on how long such videos must be to create immersion or to influence the state of mind of the seniors.

During the individual four interviews of each subject, the questionnaire always remained identical. The first question of the questionnaire was dedicated to the responsible nurse to record whether the subject was under the influence of emotion-altering medication such as antidepressants, tranquilizers, or neuroleptics during the interview. The remaining three questions were used to record the subject's state of mind using the present happiness subscale from the *Questionnaire for the Assessment of Happiness* (Ciccarello and Reinhard 2014).

Before the actual data collection, (socio-) demographic data such as gender, age, native language, former occupation, previous illnesses, and spatial mobility of the subjects were recorded through a preliminary questionnaire, as well as technology acceptance using the corresponding subscale Technology Acceptance from the Short Scale Technology Commitment (Neyer et al. 2016). Paper-based questionnaires were used in both the pre-survey and the actual data collection.

Two questions were integrated into the intervention checklist: Did anything bother the subject during the virtual journey? and Did the subject feel uncomfortable or even queasy during the virtual journey? The first question aimed at the convenience of the experience, while the second question taps the occurrence of the side effect motion sickness.

The feedback interview was intended to evaluate both the usability of the system and the methodology used to conduct the study concerning field implementation.

Therefore, a structured interview was performed with the people responsible for the implementation. The first ten questions were aimed at the usability of the system for playing the 360° videos. To determine an overall score for the usability of the system, the System Usability Scale (SUS) was used (Brooke 1996). Besides, open-ended questions were asked to identify potential weaknesses as well as strengths of the system.

Further, those responsible for implementation were asked how they felt about the organizational concept of data collection on-site.

Ethical considerations

Based on the Declaration of Helsinki and adherence to the ethical principles of medical research, obtaining an ethics vote was not required. No sensitive or critical content was shown in the 360° videos. Written informed consent was obtained from each participant before participation in the study. The intervention posed no health risk to the subjects. Only possible side effect, *motion sickness*, which was not harmful to health, was included in the education of the subjects before signing the informed consent form. Refusal or discontinuation were possible at any time.

The subjects were also informed prior to consent that their data would be pseudonymized. The reason for this procedure was that the persons responsible for the implementation had to be able to understand whether the correct test person was sitting in front of them for the interview or the intervention. In addition, the questionnaires of each session had to be labeled as belonging together and it also had to be possible to assign them to the corresponding (socio-) demographic data. This aspect was ensured by the use of a so-called *key*. This consisted of a password-protected Excel file, whereby only authorized persons were granted access. The pseudonymization was also realized computer-aided by the possible output of four random letters by means of the random function in Excel. All documents for the study implementation and evaluation were only provided with the abbreviation for the subjects and the abbreviation for the institution. Nursing facility staff were not required to sign an additional privacy statement because it was assumed that it had already been signed for the institution.

Results

Evaluation of the pre-survey

The pre-survey to collect demographic data and technology acceptance could be conducted with 28 residents (of which 8 were male = 28.6% and 20 were female = 71.4%). The mean age was 83.50 (SD= ±8.08) years. Regarding technology acceptance, the sum score averaged 14.07 (n=28; SD= ±3.07) points. The lowest score given was 8.00 points and the highest score was 20.00 points. If the four sub-questions are considered separately, the following picture emerges the mean value of the sub-score for agreement with the first statement Regarding technical new developments "I am very curious" was 3.82 (n=28; SD= ±0.98) points. For the second sentence "I quickly

take a liking to new technical developments" respondents awarded an average of 3.68 (n=28; SD= ±1.06) points, and for the third statement "I am always interested in using the latest technical devices" an average of 2.86 (n=28; SD= ±1.27) points. On average, residents awarded 3.71 (n=28; SD= ±3.71) points to the statement I would use tech products much more often than I currently do if I had the opportunity.

Description of the study population

The actual data collection was performed exemplarily on 17 subjects (of whom 6 were male = 35.3% and 11 were female = 64.7%) with a mean age of 84.29 (SD= ±8.48) years from three nursing facilities. The youngest subject was 62 years old and the oldest was 94 years old. All subjects voluntarily participated in the study and spoke German as their native language. 76.5% of the subjects (n=13) who participated in the actual data collection did not have dementia, while four subjects (23.5%) had dementia. There were a total of nine subjects in the control group (4 males = 44.4% and 5 females = 55.6%) and eight subjects in the test group (2 males = 25.0% and 6 females = 75.0%). The sum score of technology acceptance for the subjects averaged 14.41 (n=17; SD= ±3.71) points. The lowest reported score was 8.00 and the highest score was 20.00 points. In the test group, the average technology acceptance was 13.75 (n=8; SD= ±4.17) points and in the control group, it was 15.00 (n=9; SD= ±3.39) points. The mean age in the test group was 85.25 (n=8; SD= ±7.85) and in the control group 83.44 (n=9; SD= ±9.40) years. Regarding age and reported technology acceptance, the two groups (test and control) did not differ significantly. Three subjects were suffering from Dementia in the control group (33.3%) and one in the test group (12.5%). The following pre-existing conditions (apart from dementia) were found in the test group: Hypertension (n=3), Hypercholesterolemia (n=1), Stroke (n=2), Vertigo (n=1), Malignant tumor (n=2), Chronic renal insufficiency (n=3), Diabetic patients (n=2), Depressive disorder (n=1), Heart failure (n=2), Parkinson's disease (n=1), Lymphedema (n=1), Chronic gastritis (n=1), Polyneuropathy (n=1), Epilepsy (n=1), and Osteoarthritis (n=1). Two of the three institutions that participated in the actual data collection already had the VR goggles in use. One institution (DRKP) did not yet have the device.

Changes in the state of mind

The evaluation of the checklists did not reveal any deviations from the experimental protocol during on-site implementation (neither for the interviews nor for the interventions). Only one subject did not complete all sessions as planned

Table 1. Mean values of reported current happiness for each survey averaged values for days one and two, and differences between each session and day categorized by test and control group

Einteilung in Test-oder Kontrollgruppe		LGST1S1	LGST1S2	LGST2S3	LGST2S4	LGST1	LGST2	DiffS3S1	DiffS4S2	Diff2T1	DiffS3T1	DiffS4T1
Kontrollgruppe	Mittelwert	6.1852	6.7778	6.6296	6.4074	6.4815	6.5285	.4444	-.3704	.0370	.1481	-.0741
	N	9	9	9	9	9	9	9	9	9	9	9
	Std.-Abweichung	1.58211	1.23603	1.46671	1.91324	1.36026	1.44924	1.24722	1.07296	.86111	1.16203	1.32054
	Minimum	4.67	5.67	5.00	3.33	5.33	4.33	-1.33	-2.67	-1.67	-1.33	-2.67
	Maximum	9.00	9.00	9.00	9.00	9.00	9.00	2.33	1.33	1.00	2.17	2.50
Testgruppe	Mittelwert	5.9583	6.4583	6.9583	7.0952	6.2083	7.0476	1.0000	.5714	.9048	.7500	.9524
	N	8	8	8	7	8	7	8	7	7	8	7
	Std.-Abweichung	1.32662	1.06812	1.22717	1.28689	1.04938	1.19301	1.62324	1.25778	1.30475	1.46385	1.24987
	Minimum	4.00	4.67	5.00	4.67	4.83	5.33	-1.00	-.33	-.50	-.83	-.17
	Maximum	8.00	7.67	8.67	8.67	7.83	8.67	3.67	3.33	3.50	3.50	3.50
Insgesamt	Mittelwert	6.0784	6.6275	6.7843	6.7083	6.3529	6.7500	.7059	.0417	.4167	.4314	.3750
	N	17	17	17	16	17	16	17	16	16	17	16
	Std.-Abweichung	1.42658	1.13580	1.32781	1.65496	1.19443	1.32777	1.41854	1.21640	1.12875	1.30711	1.35332
	Minimum	4.00	4.67	5.00	3.33	4.83	4.33	-1.33	-2.67	-1.67	-1.33	-2.67
	Maximum	9.00	9.00	9.00	9.00	9.00	9.00	3.67	3.33	3.50	3.50	3.50

and was not present for the fourth interview on day two in the evening.

Mean current happiness in the first session in the morning on day one was 5.96 (n=8; SD= ±1.33) points in the test group and 6.19 (n=9; SD= ±1.58) points in the control group (Table 1). In the second session on the first day's evening, the mean score for current happiness was 6.46 (n=8; SD= ±1.07) in the test group and 6.78 (n=9; SD= ±1.24) points in the control group, which results in a mean score for current happiness in the test group of 6.21 (n=8; SD= ±1.05) and the control group of 6.48 (n=9; SD= ±1.36) points. No significant differences were found in mean present happiness during the first session on day one in the morning, during the second session on day one in the evening, and mean present happiness on day one between the two groups (test and control). Among all subjects (n=17), a significant difference (p=0.033) of 0.55 (n=17; ±0.97) points on average was found between the reported present happiness in the survey on the first day in the morning and the evening.

On the second morning (immediately after the intervention within the test group), the mean value of present happiness for the third interview was 6.96 (n=8; SD= ±1.23) points in the test group and 6.63 (n=9; SD= ±1.47) points in the control group. On the second day evening, the mean indication of current happiness was 7.10 (n=7; SD= ±1.29) points in the test group and 6.41 (n=9; SD= ±1.91) points in the control group. Considering the average reported current happiness of the second day, that is, the arithmetic mean of the third and fourth sessions, this results in 7.05 (n=7; SD= ±1.19) points within the test group and 6.52 (n=9; SD= ±1.45) points within the control group. No significant differences were found between the test and control group for the reported current feeling of happiness in the morning and evening of the second day or the average scores of the second day.

From the first to the third interview, the value of the stated present happiness increased by an average of 1.00 (n=8; SD= ±1.62) point in the test group and 0.44 (n=9; SD= ±1.25) points in the control group. Between the second and fourth interviews, reported current happiness increased by an average of 0.57 (n=7; SD= ±1.26) points in the test group and decreased by an average of 0.37 (n=9; SD= ±1.07) points in the control group. There were 0.90 (n=7; SD= ±1.30) points between the averaged value for the first day and the mean value for the second day in the test group and 0.04 (n=9; SD= ±0.86) points in the control group. From the averaged value for the first day to the third session, there were a mean gain of 0.75 (n=8; SD= ±1.46) points in the test group and 0.15 (n=9; SD= ±1.16) points in the control group. An average increase of 0.95 (n=7; SD= ±1.25) points was seen in the test group from day one to session four. In the control group, stated current happiness decreased by 0.07 (n=9; SD= ±1.32) points from day one to the fourth interview. Overall, for the listed changes in stated present happiness between the test and control groups from session one to session three, from day one to day two, and from day one to sessions three and four, respectively, no significant difference s were demonstrated. Similarly, no significant difference was found between the test and control groups for the change in reported present happiness from the second to the fourth session.

No significant change could be found within the test group between the indicated present happiness in the first session and that in the third session as well as between the indicated present happiness in the second and fourth session. Also from day one to day two as well as from day one to the third or fourth session, no significant change could be found.

Within the control group, no significant change in stated present happiness can also be detected between the first and third or between the second and fourth interviews. No significant changes in reported present happiness from day one to day two and from day one to the third and fourth sessions, respectively, can be detected within the control group.

After the intervention, one subject in the test group reported that the image remained blurry and difficult to see. Three subjects talked a lot after the intervention and also three subjects emotionally reproduced what they saw. One subject was completely fascinated to be able to see again with an almost blind eye. None of the subjects from the test group stated that they felt queasy or nauseous during or after the intervention. When asked if anything had bothered them during the trip, 87.5% of the subjects from the test group answered No and only one subject indicated that he/she would have liked to see more sharply.

Five of the subjects were under the influence of emotion-altering drugs during at least one interview. All of these subjects were under the influence of emotion-altering medication during all four interviews. Four of them belonged to the control group and one to the test group. The following scatter plot in average reported current happiness from the third and fourth interviews for each subject as a function of influence by emotion-altering drugs shows the averaged current happiness for the second day for each subject depending on whether the subject was under the influence of emotion-altering medication at the time of the interview (Fig. 1).

Spearman's correlation test shows the following among subjects who did not have dementia for the first session: There is a significant ($p<0.05$) positive correlation ($r=0.65$) between the question about the mood in the last half hour and the question about feeling in the moment. Similarly, a highly significant ($p<0.01$) positive correlation ($r=0.83$) is shown between the question about the face that best describes the momentary feeling and the question about the feeling right now. A significant ($p<0.05$) positive correlation ($r=0.67$) also exists for this session

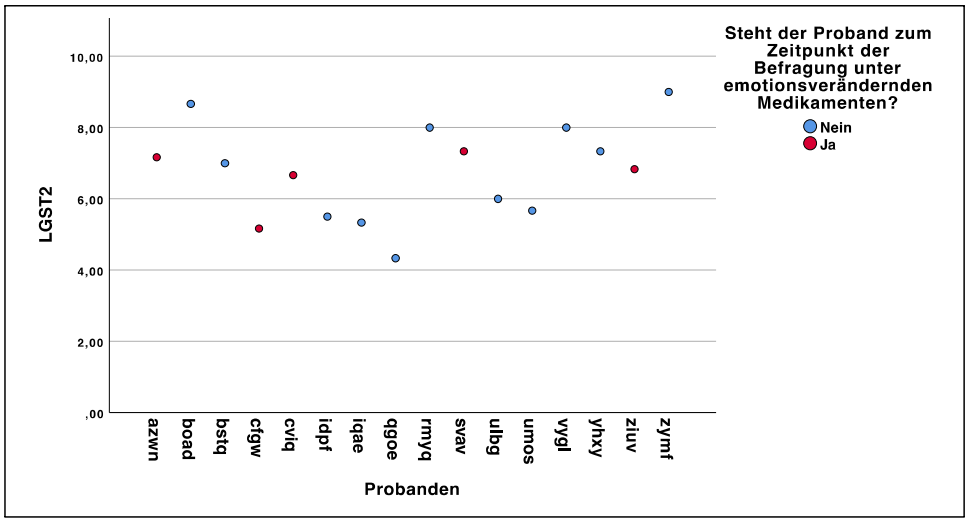

Fig. 1. Average reported current happiness from the third and fourth interviews for each subject as a function of influence by emotion-altering drugs

and all subjects without dementia for the question about the mood in the last half hour and the question about the face that best expresses the instantaneous feeling. For the second session, no significant correlation is shown for the subjects without dementia concerning the data on the recording of present happiness between the question about the mood in the last half hour and the question about the face that best expresses the present feeling. A highly significant ($p<0.01$) positive correlation ($r=0.77$) presents itself between the question about the mood in the last half hour and the feeling at the moment. There is no significant correlation between the question about the face that best expresses the momentary feeling and the feeling at the moment in this second survey among the subjects who do not suffer from dementia. In the third survey to elicit present happiness, there is no significant relationship between the question about the mood in the last half hour and the face that best describes the present feeling for the subjects without dementia. Similarly, no significant correlation can be found between the question about the instantaneous feeling and the mood in the last half hour. A highly significant ($p<0.01$) positive correlation ($r=0.82$) can be demonstrated for the question about the momentary feeling and the face that best expresses the momentary feeling. A significant ($p<0.05$) positive correlation ($r=0.70$) between the question about the mood in the last half hour and the face that best expresses the instantaneous feeling is found for all subjects without a dementia condition during the fourth interview. For the question about the mood in the last half hour and the questions about the momentary feeling a highly significant ($p<0.01$) positive correlation ($r=0.73$) is shown. There is also a highly significant ($p<0.01$) positive correlation ($r=0.74$) between the statements on the question also about the momentary feeling and the question about the face, which best describes the momentary feeling. For the group of subjects with dementia, no significant correlation could be demonstrated within any of the four sessions for the data on the individual questions.

Possible influencing factors on the changes in the state of mind

No statistically significant correlation was found between the variable age and the individual variables for the change in the state of mind within the test group.

The mean value for the change in present happiness from the first to the third session was -0.67 (n=2; SD= ±0.47) points among men, while it was 1.56 (n=6;1.47) points among women. For the difference between the second session and the fourth, there was an increase of 0.17 (n=2;0.24) points for men and 0.73 (n=5;1.50) points for women. Comparing the averaged value for the first day and the averaged value for the second day, it shows an increase of 1.37 (n=5;1.26) points in females and a decrease of 0.25 (n=2;0.35) points in males. An increase of 1.25 (n=6;1.34) points was recorded in the female subjects from the averaged value of the first day to the third session. In contrast, a decrease of 0.75 (n=2;0.12) could be observed for men. From the averaged value from day one to session four, an increase of 1.23 (n=5;1.38) was seen among female subjects, and an increase of 0.25 (n=2;1.38) points among males. The Eta coefficient for the difference in reported current happiness between the first and third sessions and gender yields a value of 0.63, meaning that 39.7 percent of the variance in the change of mood from the first to the third session can be explained by gender. Comparing only women, a significant ($p=0.049$) change in reported current happiness can be found from the first to the third session. On average, this shows an increase of 1.56 (SD= ±1.47) points.

For subjects who were mobile with a walker (n=5), there was a mean increase of 2.00 (SD= ±1.11) points between the first and third sessions. For those subjects in wheelchairs

(n=3), there was a decrease of 0.67 (SD= ±0.33) points. The eta coefficient of the difference in reported present happiness from the first to the third session and the spatial mobility of the subject is 0.85. Thus, 72.3 percent of the variance in the change in reported present happiness from the first to the fourth session can be accounted for by the spatial mobility of the subjects. From the second to the fourth session, reported present happiness increased an average of 0.73 (SD= ±1.50) points among subjects with a walker and an average of 0.17 (n=2; SD= ±0.24) points among subjects in a wheelchair. Among wheelchair-bound subjects, current happiness decreased by an average of 0.25 (n=2; SD= ±0.35) points from day one to day two. Among subjects mobile with a walker, current happiness increased by a mean of 1.37 (SD= ±1.26) points. Among subjects who were wheelchair-bound, there were a decrease of 0.50 (n=3; SD= ±0.44) points from day one to the third session and an increase of 0.25 (n=2; SD= ±0.59) points for comparison with the fourth session. Among subjects who coped with a walker, an increase of 1.50 (SD= ±1.33) points was noted from day one to session three and an increase of 1.23 (SD= ±1.38) points to session four. A significant (p=0.016) change of 2.00 (SD= ±1.11) on average can be demonstrated among subjects who were mobile with a walker for the reported current happiness in the first and third sessions. Among subjects who did not have any form of dementia, reported current happiness increased by an average of 1.29 (±1.52; n=7) points from the first to the third session.

From the second to the third interview, it increased by a mean of 0.67 (n=6; SD= ±1.35) points. Considering the mean of the first and second interviews as day one and the mean of the third and fourth interviews as day two, there were an average increase of 1.14 (n=6; SD= ±1.26) points from day one to day two in the group without a dementia condition. By 0.98 (n=7; SD= ±1.42) points, reported current happiness increased on average within the group without a dementia condition from day one to session three. From day one to session four, there was a mean increase of 1.14 (n=6; SD= ±1.26) in the same group. For the subject who suffered from some form of dementia, a minus of 1.00 point was noted from the first to the third interview. No change was noted between the reported present happiness of the second and fourth sessions. By 0.50 points, the mean value increased from the first day to the mean value of the second day. From the average value of the first day to the third session, there was minus of 0.83 for the subject with dementia disease. By -0.17, the value of the reported present happiness changed from the mean value of the first day to the fourth session in the subject with a dementia-related disease. Figure 2 visualizes the mean differences of the stated happiness depending on the presence of a dementia-related disease within the test group.

No significant correlation can be found between the reported present happiness on day one (morning, evening, and the mean value for day one) and the changes in reported present happiness between the sessions and days.

For the intervention, 360° video were randomly assigned to the subjects. A 360° video could be assigned to multiple categories. A video that was assigned to the category animals, among others, was allocated to four subjects. On average, the reported happiness of this subjects increased by 1.42 points from the first to the third interview. From the second to the fourth session, the stated current happiness increased by an average of 0.75 points among all subjects who had viewed a video assigned to this category. The mean value of the first day and the mean value of the second day differed by an average of 1.08 points in the same group. From the average value of the first day to the indicated present happiness in the third session, there was an increase of 1.25 points on average. By another 0.92 points the value of the stated present happiness in the group of subjects who had watched a 360°

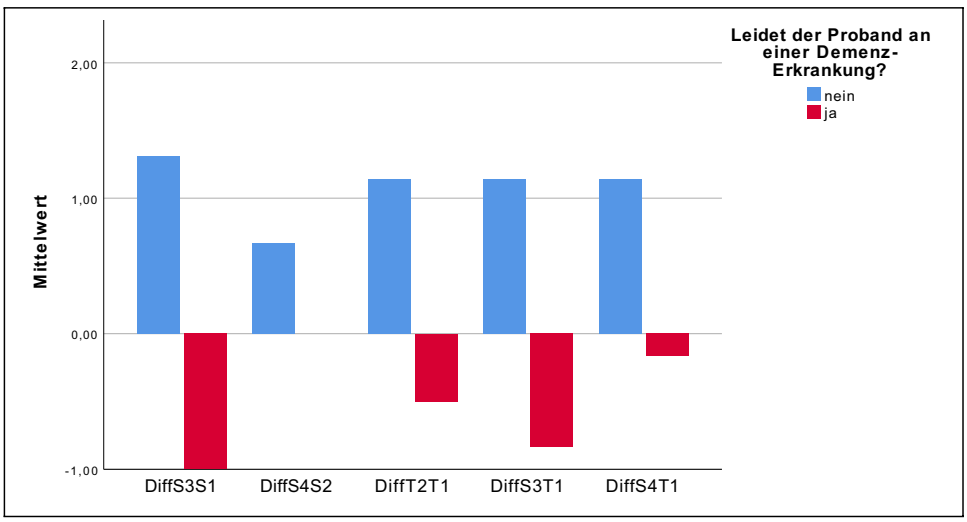

Fig. 2. The average change in reported current happiness as a function of having dementia disease

video of the category animals increased from the mean value of the first day to the fourth session. Three subjects watched a 360° video that was assigned to the category among people, among others. On average, these subjects experienced a 1.33-point increase in reported happiness from the first to the third interview. From the second to the fourth session, the stated current happiness increased by an average of 1.67 points among all subjects who had watched a video assigned to the among people category. The mean value of the first day and the mean value of the second day differed by an average of 2.00 points in the same group. From the average value of the first day to the indicated current happiness in the third session, there was an increase by an average of 1.11 points. By another 2.33 points the value of the stated present happiness in the group of subjects who had watched a 360° video of the category among people increased from the mean value of the first day to the fourth session.

Table 2 show average changes in reported current happiness between sessions split by categories of the viewed 360° videos.

Overall, no significant correlation can be found between the length of the 360° videos and the different variables for the differences between sessions and days.

A significant linear relationship between the changes in reported current happiness between sessions and days and the reported technique acceptance was not demonstrated (Fig. 3).

The result of Spearman's correlation test shows that there is a highly significant (p=0.009) negative correlation (r=-0.84) between the level of agreement to the statement I am always interested in using the latest technical devices. and the change in the stated present happiness from the first to the third session (Fig. 4).

Also, a significant (p=0.043) negative correlation (r=0.77) was found for the level of agreement to this statement mentioned above and the change in stated present happiness from the first to the second day. With the difference between the first day and the fourth session, the agreement to the statement mentioned above shows a significant (p=0.026) negative correlation (r=-0.82).

The participating institution with the acronym AWSO had an average increase in reported current happiness

Table 2. Average changes in reported current happiness between sessions split by categories of the viewed 360° videos

kategorien des gesichteten 360° Videos							
	Natur Mittelwert	Tiere Mittelwert	Entspannung Mittelwert	Action Mittelwert	Unter Menschen Mittelwert	Stadt Mittelwert	Bildung Mittelwert
DiffS3S1	1.07	1.42	1.07	1.67	1.33	-.50	-.33
DiffS4S2	.07	.75	.07	1.83	1.67	.33	.33
DiffT2T1	.57	1.08	.57	1.75	2.00	.00	.00
DiffS3T1	.63	1.25	.63	1.42	1.11	-.33	-.67
DiffS4T1	.50	.92	.50	2.08	2.33	.67	.67

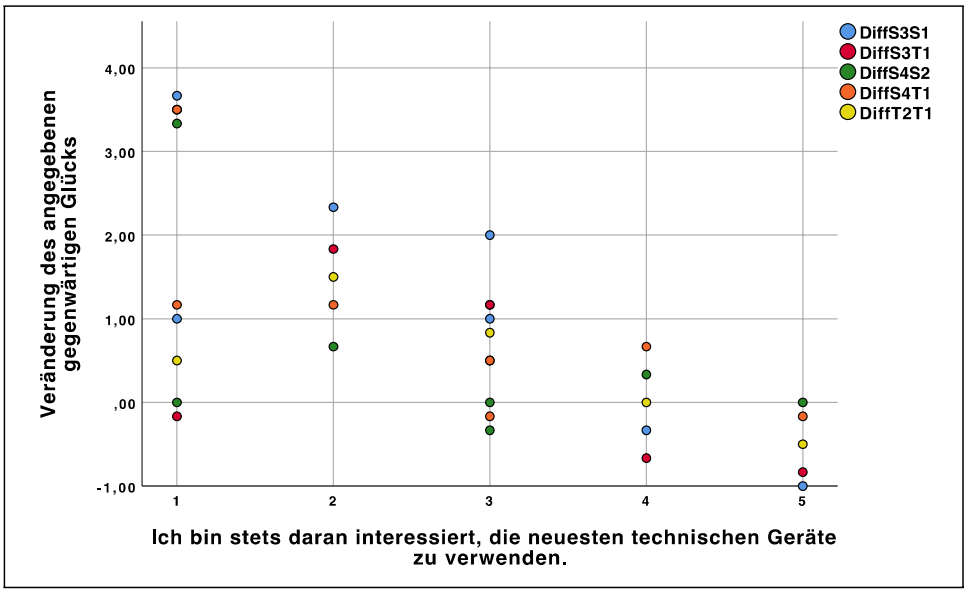

Fig. 3. The average change in reported current happiness as a function of agreement with the statement "I am always interested in using the latest technological devices"

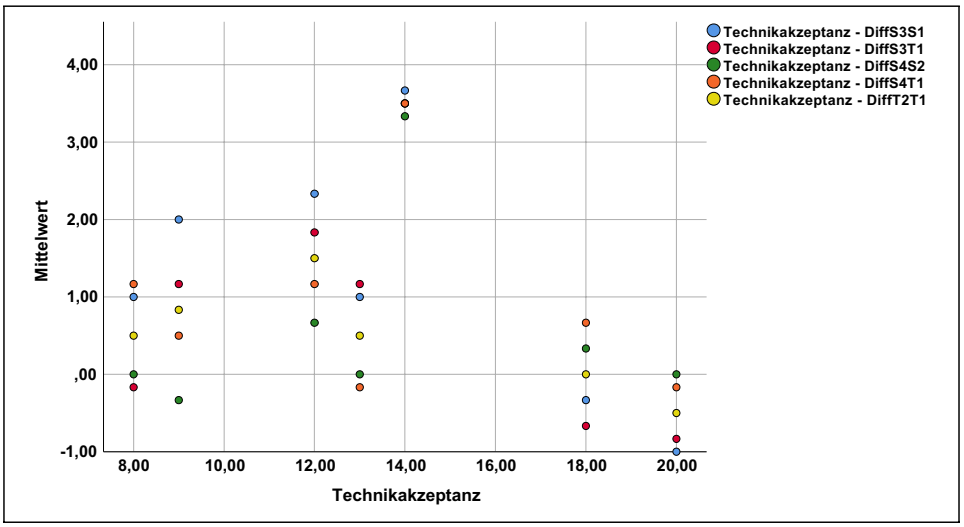

Fig. 4. The average change in reported current happiness as a function of subjects' technology acceptance

of 0.67 (n=2; SD= ±2.36) points from the first to the third survey. For the same period, the facility with the acronym CUZW had a mean increase of 1.50 (n=2; SD= ±3.06) and the facility with the acronym DRKP had an increase of 0.92 (n=4; SD= ±0.96) points. For the change in reported current happiness from the second to the fourth session, within the institution AWSO, there is a mean increase of 0.33 (n=2; SD= ±0.47) points. Within the institution with the acronym CUZW, one subject's reported present happiness changed by 3.33 points. The second subject was not present at the fourth session. In the institution with the abbreviation DRKP, the value for the stated present happiness remained the same on average between the second and the fourth interview (n=4; SD= ±0.27). The mean score for the first day was, on average, 0.50 points lower than the mean score for the second day at the institution AWSO. For the one subject belonging to the institution with the acronym CUZW, the second day mean was also higher, by 3.50 points. At the institution DRKP, the mean score increased by 0.46 (n=4; SD= ±3.44). By an average of 0.50 (n=2; SD= ±1.89) points, the value of reported current happiness increased from the averaged value for day one toward the third interview in the institution AWSO. There was an average increase of 1.75 (n=2; SD= ±2.47) for the same period at the CUZW institution and an increase of 0.38 (n=4; SD= ±0.94) points at the DRKP institution. From the averaged value reported for the current happiness on the first day to the fourth session increased by an average of 0.50 (n=2; SD= ±0.94) points at institution AWSO. For the subject from the CUZW institution, an increase of 3.50 points was seen for the same period, and at the DRKP institution, the value increased by an average of 0.54 (n=4; SD= ±0.55) points. The average change in reported current happiness of subjects in the test group between sessions and days categorized by the institution clarifies these results (Fig. 5).

Usability of the application

For the System Usability Scale, the mean value results in 80.00, with the smallest value is given being 65.00 and the maximum being 90.00 (n=4). One Person responsible for implementation on site indicated in response to the open-ended questions that the operation using the cursor was perceived as particularly good. Two respondents agreed that they particularly liked the ease of use and that the selection of films had been very appropriate. The fact that the setting can be selected so that a bedridden patient sees the most interesting part of the video was mentioned once in this context. So was the statement that the categorization of the videos was particularly pleasing. Two implementers stated that they found being in the middle of the action through 3D and 360° function particularly positive. Once cited the ease of switching from the 360° mode to the cinema hall view as a positive. All respondents listed that the ability to operate externally would be a desirable improvement. Likewise, all respondents agreed that an improvement should be made to the sharpness adjustment function. Seventy-five percent of respondents agreed that they lacked a way to follow the video on the screen externally from the resident's point of view. Twice the weight of the glasses was criticized and one respondent listed the waiting time until the glasses were up and the video was selected for the resident.

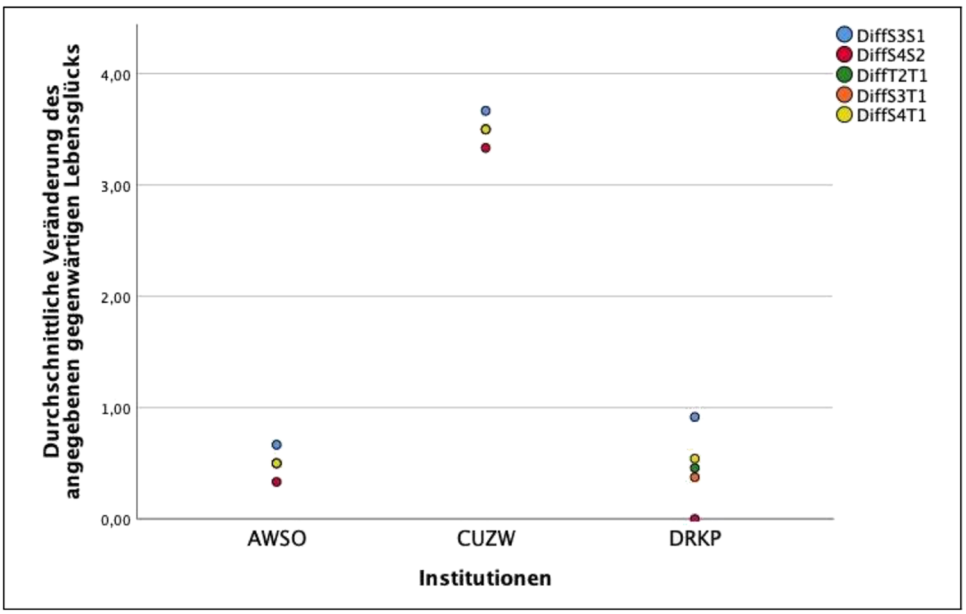

Fig. 5. The average change in reported current happiness of subjects in the test group between sessions and days categorized by the institution

Discussion

Changes in the state of mind

To record the change in the state of mind, an inter-individual and an intra-individual comparison of the subjects was carried out. Both the absolute values of the state of mind after viewing the 360° videos in the test group and the relative changes were compared between the test and control group. For the absolute values of the indicated present happiness, after the intervention in the test group, no significant difference could be found between the test and the control group, which can be attributed to the intervention. Nevertheless, both for the third session (TG:6.96; KG:6.63) immediately after the intervention, and for the fourth session (TG:7.10; KG:6.14) and the whole second day (TG:7.05; KG:6.52), the mean value is higher in the test group than in the control group, respectively. These results and the fact that the basic mood or the stated current happiness in the first (TG:5.96; KG:6.19) and second (TG:6.46; KG:6.78) sessions (before the intervention in the test group) and thus also the mean value for day one (TG:6.21; KG: 6.48) was higher in the control group in each case and then reversed, prove the tendency for a positive effect of viewing 360° videos. The fact that no significant results were found could result from the small number of subjects. Due to the small number of subjects, outliers could have particularly influenced the result. Also, visits, which were only possible to a limited extent due to the current pandemic situation, could have caused particularly strong fluctuations. These special events were only documented for a few subjects. Equivalently, within the test group, there was a larger mean increase in reported current happiness between the reported sessions. But again, no significant difference could be found. Analogous to the pre-post design, the state of mind before and after viewing the 360° video was compared within the test group and tested for a significant change. Again, no significant change in reported current happiness was found. Nevertheless, increases in stated present happiness were noted from session one to session three (1.00±1.62), from session two to session four (0.57±1.26), from day one to day two (0.90±1.30), from day one to session three

(0.75±1.46), and from day one to session four (0.95±1.25), respectively. The subjects' qualitative statements and emotional replay of what they saw confirmed this positive trend of the intervention. In contrast, within the control group the changes in stated present happiness are significantly lower and in some cases even negative. This reinforces the assumption that the increase in the state of mind in the test group is attributable to the aforementioned intervention (the viewing of 360° videos). Appel et al. also observed the positive feedback when viewing 360° videos from older adults with cognitive and/or physical impairments (Appel et al. 2020). Other studies found significant improvement in alertness and enjoyment in seniors with dementia (Rose et al. 2019; Moyle et al. 2017).

All five subjects who have to take an emotion-altering medication (such as antidepressants, tranquilizers, or neuroleptics) were under the influence of these medications during all interviews. Regular intake can be assumed. Therefore this could only reduce the comparability between the test and control groups with regard to the absolute values since one subject in the test group and four subjects in the control group were under the influence of emotion-altering drugs. However, the diagram in Average reported current happiness from the third and fourth interviews for each subject as

a function of influence by emotion-altering drugs 1 shows that the data on the current happiness of the subjects, who were under the influence of emotion-altering medication, are very scattered among the data of the other subjects. So an influence of these medications on comparability tends not to be assumed.

As a tendency, it could be assumed that the effect is longer-lasting since the mean value of the test group was also higher in the fourth session than in the control group (TG:7.10; KG:6.14). This assumption is confirmed by the fact that the reported present happiness in the corresponding session on the first day in the evening was lower on average in the test group than in the control group (TG:6.46; KG:6.78). Nevertheless, other factors that influenced the result and possible confounding variables cannot be excluded.

Within the entire study population, a significant intraindividual difference (p¡0.05) was found between the first day morning and evening. This aspect confirms the assumption that time-of-day mood variations occur within the target group and that mood is on average 0.55 (±0.97) points worse in the morning than in the evening.

Overall, the present work confirms the statements of previous studies that viewing 360° videos is therapeutically valuable and promotes emotional well-being (Browning et al. 2020a; McMahan and Estes 2015; Negrín et al. 2017; Yu et al. 2018; White et al. 2018).

Possible influencing factors on the changes in the state of mind

The factors influencing the change in the state of mind through the viewing of 360° videos could only be analyzed within the test group, which implies an even smaller number of test subjects. No significant correlation was found between age and the change in the state of mind.

If we look at the change in the state of mind as a function of gender, we see a significantly greater increase in the female subjects. However, this effect could also be due to the unequal distribution of gender within the test group (male: n=2; female: n=6). Comparing only the sessions one and three of females within the test group, a significant change in current happiness by an average of 1.56 points (SD= ±1.47) can be observed (p¡0.05). This may indicate that women are more receptive to this type of entertainment.

A clear trend can also be seen when categorizing changes in subjects' reported happiness by spatial mobility. 72.3 percent of the variance in change in the state of mind from the first to the third session was due to spatial mobility. Subjects in wheelchairs reported a much smaller mean change in current happiness, which was also mostly in the negative range. Again, a significant improvement (p¡0.05) in present happiness by a mean of 2.00 (SD= ±1.11) between the first and third sessions was found only among the mobile subjects with a walker.

Baseline mood seemed to tend to not influence the individual changes in reported happiness). This justifies that also the absolute values could be compared between the test and the control group, although the basic mood was higher in the control group than in the test group.

The subjects in the test group who viewed a 360° video from the category among people achieved the highest values for the individual differences overall. They were closely followed by the category Action and Animals. Here it should be noted that a video was assigned to multiple categories and very few subjects viewed a video from each category. However, these results, apart from the very small number of subjects, may also be due to the current pandemic situation, the social distancing and the resulting consequences of social distancing mentioned at the beginning of this paper. Nevertheless, the results showed that not only virtual natural environments can improve the state of mind, but also that many different categories have an effect on the residents' wellbeing and are well accepted. Especially in terms of variety, a wide range of different categories of 360° videos should be available in care facilities. Anderson and his colleagues already emphasized the influence of scene preference on mood in their paper. In future studies with elderly people in need of care, the focus should be less on objective categories and more on individual preferences (Anderson et al. 2017).

None of the residents prematurely aborted the intervention in the form of viewing a 360° video. Concerning the length of the viewed 360° video and the change in reported current happiness, no significant correlation was found. The previous studies, which recorded an increase in mood, also frequently used videos of 5 minutes (Yeo et al. 2020), 6 minutes (Browning et al. 2020a) or 9 minutes in length (Yu et al. 2018). Nevertheless, 15-minute videos, for example, were also used (Anderson et al. 2017). However, these were always young, healthy subjects. Appel and her colleagues recorded an average senior dwell time of 8 minutes in their study (Appel et al. 2020). In contrast, Espinoza et al. used a 30-minute session four times a week in their study to improve the well-being of cancer patients. Likewise an improvement was observed and the subjects were comparable to our target group (up to 85 years), among others (Espinoza et al. 2012).

Technology acceptance also does not seem to have a significant effect on the change in the state of mind. This could be due to the fact that the use of technology only had positive effects for the seniors in this study without having them to deal with the technology itself. The seniors only had to make themselves available and enjoy, but did not have to deal with the technology themselves.

A highly significant (p¡0.01) negative correlation (r=-0.84) is shown between the level of agreement with the statement I am always interested in using the latest technological devices and the increase in current happiness for the difference from session one to session three. A significant (p¡0.05) negative correlation was also found for the difference from day one to day two (r=-0.77) and for the difference from day one to session four (r=-0.82). This could be related to the active wording of this sub-statement in contrast to the other assertions. The seniors are presumably quite willing and interested to use the technology but do not want to actively engage with it themselves. Since this is also not necessary in the practical implementation that the residents of the facilities operate the system for playing 360° videos themselves, this aspect does not stand in the way of the implementation.

Possibly, this fact even reinforces the benefit.

The nursing home (DRKP) that introduced the VR goggles in the study was on a par with another home that had already been using them for a longer period in everyday nursing care. The institution that stood out with a particularly strong increase in reported current happiness had already been using the VR goggles before the study. However, it cannot be ruled out that some subjects from the institutions that had not yet used the VR goggles by the time of the study nevertheless had experience with virtual reality. While other subjects had no experience with it, even though the institution in which they are living in had already previously used the VR goggles in everyday care. Therefore, the present study tends to confirm existing results of previous research that previous experience with VR technology does not influence the change in mood state (Liszio et al. 2018).

If we look at the changes in current happiness as a function of the presence of dementia, we see the following: Within the test group, the differences consistently show a negative or no change in the demented subject, while the subjects not suffering from dementia consistently showed an increase. This contradicts the results of previous studys, which found positive impact of the VR experience on people with dementia resulting in significant improvements in pleasure and alertness (Rose et al. 2019) and demonstrated higher levels of enjoyment and alertness in subjects with dementia (Moyle et al. 2017). Very striking in the present study is the analysis of the answers to the sub-questions of the questionnaire for recording present happiness. Here, the demented subjects' scores are visually very far apart, especially in the third session. This could be an indication that the survey instrument used to record present happiness was inappropriately selected for the demented subjects. This aspect is discussed in the last paragraph in more detail.

Implementation in everyday care

Although technology acceptance had not proved to be an influencing factor in the present pilot study, it could have an impact on whether residents of old people's and nursing homes would use this entertainment medium in everyday life at all. The fact that the range among residents who completed the pre-survey was so wide (from a minimum of 8.00 points to a maximum of 20.00 points) could mean that people with lower technology acceptance would also engage with this new medium. Overall, technology acceptance in the pre-survey averaged 14.07 points out of a possible 20.00 points. The fact that the average technology acceptance was nevertheless in the upper midfield confirms the results of a previous study that the older generation generally has a relatively high level of acceptance with regard to new technologies (Syed-Abdul et al. 2019). The acceptance and willingness of the facilities to participate in the study were very high, which confirms the statements of existing studies (Appel et al. 2020). However, many of the recruited nursing facilities had to drop out in advance due to the pandemic crisis situation. The level of agreement with the partial statement I am always interested in using the latest technical equipment was significantly lower on average than for the other sub-statements.

In terms of user-friendliness, the average score was quite high at 80.00 percent. According to the information in the publication (Brooke 1996), this means that the usability of the system is very good, but not yet perfect. The evaluation of the open questions revealed the weak points of the system. All subjects had criticized the missing possibility of the external operation. This goes hand in hand with another point of criticism: the ability to follow the video externally on a screen from the resident's point of view. Further, the adjustment of the sharpness was criticized by all interviewed executives. In contrast, also many positive aspects of the system were mentioned, such as the fact that it is easy to use. In addition, the respondents liked the selection of films and the fact that the residents are in the middle of the virtual environment due to the 3D and 360° function. Also mentioned were the operation by a cursor, the possible setting to let a bedridden resident see the most interesting of the video, the categorization of the videos, and the ease of switching from 360° mode to the cinema room. Therefore, with the elimination of the weak points, perfect usability of the system would be possible and this would make the use in everyday care even easier and improve the experience for the residents.

Seven out of eight subjects stated that nothing disturbed them during their virtual journey. Only the subject for whom the focus setting did not work so that he could see sharply cited this after the intervention to the corresponding question. Therefore, the negative practical effects reported in previous research could not be confirmed. In

contrast to the study of Yeo et al. (Yeo et al. 2020) none of the subjects from the present study felt disturbed by the bulkiness of the HMD.

Also, the side effect of motion sickness did not occur in the present study. Despite numerous pre-existing conditions such as dizziness, epilepsy, and various heart diseases in the test group, none of the subjects stated that they felt queasy or nauseous during or after the intervention. This could be due to the professionally produced 360° videos used. Hughes and her colleagues in turn, concluded from their results that limiting the use of immersive virtual reality to a maximum duration of 20 minutes did not cause simulator-induced illness and set this limit as a best practice baseline for future applications within this older population (Hughes et al. 2017).

Discussion of the methods

Overall, the work represents the standard procedure for the complete study procedure as a concept for further subsequent studies with representative sample sizes. However, due to the very small number of subjects in the present study, its results should be interpreted with caution.

An obvious methodological weakness is the fact that the study was conducted by different persons (the so-called field investigators). However, the study was explicitly designed to be conducted in this manner. One of how objectivity or equality of observation was ensured was by describing as precisely as possible how the study was to be conducted. For this reason, a detailed experimental protocol was prepared and handed out. To make sure that this protocol was followed, the persons in charge were obliged to fill in and sign a checklist after each session. Each checklist was used to ensure that the correct subject was interviewed at the correct time, according to the experimental protocol, and that the intervention was carried out at the correct time with the correct subject and the correct video, according to the experimental protocol.

Language barriers regarding the questionnaire and communication problems during the sessions can be excluded, as within the pre-survey all subjects indicated German as their native language. Nevertheless, one person responsible for the implementation stated in the feedback interview that the subjects found it difficult to answer the questionnaire, as all questions would go in the same direction. The present happiness questionnaire is designed in such a way that a correlation of these three questions of the questionnaire can be assumed for each subject and each session. However, the results of the correlation test show that this was not always the case. It is extremely striking that among the subjects with dementia during no session even two of the total of three questions show a significant correlation. Among the subjects not suffering from dementia, at least two questions correlate in every session. All subjects with dementia are from the facility of the named implementer who made the above statement. It can be assumed that the study in this form, as originally planned, was to be conducted only with demented subjects excluded. For a study with demented subjects, an alternative survey instrument should be chosen, for example in the study by (Rose et al. 2019), and (Moyle et al. 2017).

A strength of the present pilot study is the controlled study design to avoid confounding of the intervention by other factors. Further, the virtual reality application was compared in a multicenter field study as an additional activity to the standard activities or usual entertainment programs offered in the nursing homes. Thus, practical recommendations can be made on what added value the use of VR can achieve in these facilities. Isolation due to the Corona pandemic may have represented a confounding factor here, as there may have been fewer, different, or no entertainment programs in the facilities. The possible confounding factor technology acceptance was compensated in advance by the pre-survey. And additional (socio-) demographic data were collected to generate hypotheses for possible influencing factors. Randomization ensured structural equality for a fair comparison between the test and control group. Also, a pre-post test with perfect structural equality was performed. Despite randomized allocation, bias may have occurred here due to unequal allocations of the characteristics gender and spatial mobility. These possible influencing factors were not known in advance and could only be proven in tendencies in the present work because of the small sample. Another plus point is the attention paid to diurnal variations by surveying the state of mind twice in both groups before and after the intervention in the test group. This approach is confirmed by the result that there is a significant difference ($p_{\dot{c}}0.05$) between the reported current happiness on the first day of data collection in the morning and in the evening. The use of validated scales (Technology Acceptance, Questionnaire for the Assessment of Happiness, and System Usability Scale) represents another plus.

There are some limitations to the strengths: The present work cannot make a validated statement about long-term effects with the present study design. Only a comparison with limited validity between institutions that already had VR goggles in-house and an institution that did not yet use such an application in everyday care as possible. Also, the effect of regular exposure cannot be adequately captured with the present study design. Furthermore, no reasons for non-participation were recorded.

In summary, the methods mentioned above were sufficient and appropriate for a pilot study to generate hypotheses for further research and to develop and test a concept for application in larger randomized controlled trials.

Conclusion

Implications for further research

The study presents a concept of how larger-scale studies with subsequent modifications could test the generated hypotheses, and therefore contributing to this very scarcely studied area of research.

- With a representative sample size, subjects should be stratified randomized. It was shown a possible influence of gender and spatial mobility, so these characteristics should be taken into account.
- For the selected survey instruments, residents with dementia disease should be excluded. If this is not desired, an alternative survey instrument should be chosen for these subjects, such as a physical measurement combined with observations during the intervention.
- Also recommended is the use of an electronic questionnaire to avoid errors in the transmission of large amounts of data.
- In addition, the identified usability problems should be eliminated in advance. The main issues here are as follows: The focus adjustment function should be improved and the possibility of external operation in conjunction with a screen, so that caregivers can view the resident's video externally, should be implemented.
- Even though the side effect Motion Sickness did not occur in the present study, for an area-wide study the content should be tested in advance on young and healthy subjects regarding this side effect.

Conclusion Overall, the present study was able to demonstrate a positive effect of viewing 360° videos on the state of mind of nursing facility residents. Due to the very small sample size caused by the pandemic, no significant changes could be found as a result of the intervention. Nevertheless, the average statements of current happiness are higher in the test group after the intervention than in the control group, and this even though the baseline mood was higher in the control group than in the test group. Overall, the effect seems to be larger in women than in men. Possibly spatial mobility also influences the effect of viewing 360° videos on the state of mind. Also, aversion to using the technology oneself could be related to an all the higher positive effect. The positive effect of the 360° videos on the state of mind of the residents in combination with the very emotionally enthusiastic statements of the test persons during or after the intervention and the willingness to participate in the study also indicates a high willingness to use this possibility of entertainment in everyday life. Furthermore, the willingness of the nursing staff to participate in this study was also very high despite all the circumstances. The statements in the feedback conversation confirmed the assumption and together with the very high usability value for the application, it can also be assumed that there is a very high willingness to implement it in everyday care. The present pilot study shows tendencies and thus generated hypotheses for subsequent randomized controlled in-the-field studies, which investigate these hypotheses on a larger sample. Thus, valid results can be obtained in this relevant and promising field of research with practical relevance. Therefore, the results are not intended to be absolute, but to provide direction for further larger-scale studies. Besides, a concept for conducting a multicenter randomized controlled trial was developed and evaluated. Like (Moyle et al. 2017; Appel et al. 2020) and (Rose et al. 2019), this work can confirm that virtual reality has the potential to improve seniors' quality of life. To establish Virtual Reality in caregiving, there are still some hurdles to overcome. The basis for this is sound scientific knowledge. Especially during the current situation, the urgency of implementing such technologies is again coming strongly to the fore.

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Authors´ contributions SSG: conceived the study and wrote the manuscript, access to participating nursing facilities ensured
AW: created the 360° videos and made them available free of charge
TT: manuscript corrected and revised, revision of the discussion
TS: Questionnaire co-developed and approved, manuscript corrected and approved, access to participating nursing facilities ensured
SH: Support with statistical analysis, manuscript corrected and approved, project responsibility

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Data availability The data set is provided as an e-supplement.

Code availability SPSS syntax is provided upon request.

Declarations

Ethics approval An ethics vote was not required. No personal data and sensitive measured values were collected. A standardized questionnaire was used to assess well-being and technology affinity during 360° video viewing.

Consent to participate Written informed consent was obtained from all participants at the beginning of the questionnaire.

Consent for publication Not necessary as no sensitive patient data is reported. Only anonymized results are presented.

Conflicts of interest The authors declare no conflicts of interest.

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