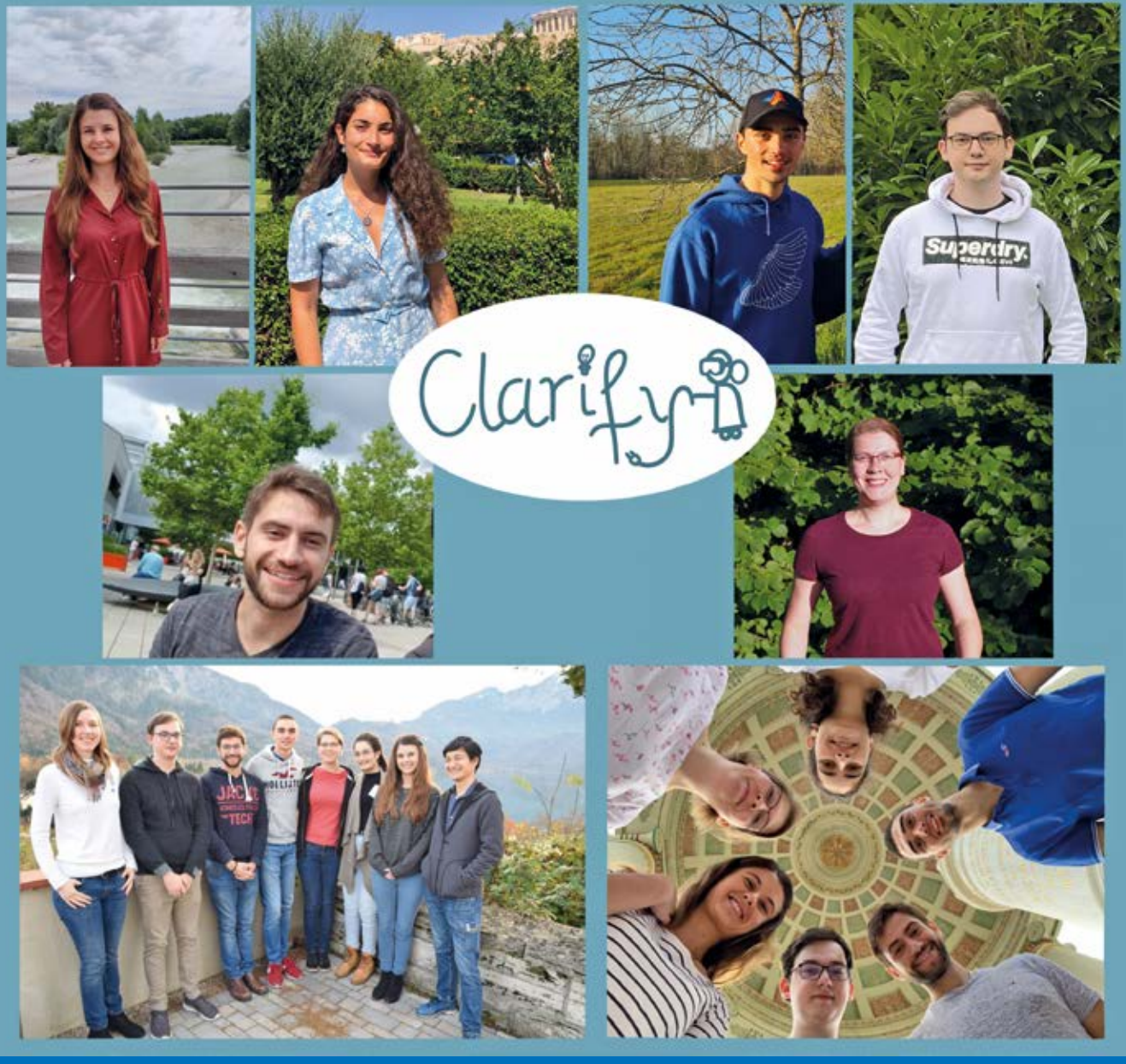
Clarify
Superdry

Project Report **Clarify**

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Preface by the Supervisors

Prof. Dr. Daniel Pittich and Silke Schmidt

Digital Technologies play a predominant role in our work as well as our private and social life. Students today – even the youngest learners – are "digital natives." Technology use, thus, has become an integral part of education in its own right, since everyday practice at all educational levels is no longer possible without it. These technologies include the visualization of 3D data, thus Virtual and Augmented Reality (VR and AR), together: eXtended Reality (XR).

However, this shift to a digitized life presents great challenges not only to youth but also, and mainly, to older age groups. *Technology acceptance* can be seen as a precondition for all educational stakeholders of integrating smoothly within this new high-tech scenario. In this respect, the topic of VR and AR is at the center of the debate. For a long time, virtual reality was often associated with computer and online gaming and therefore not highly appreciated by many – especially in Germany – and seen as a technology with solely recreational purposes. But this is not the case: Industry has been using XR technologies for decades to develop new products and environments and to work collaboratively globally. Positive effects in the healthcare sector have been studied and proven for a long time, too. Therefore, it is of great importance that the team Clarify chose virtual reality to study senior citizens' technology acceptance. Putting the focus on this age group is crucial, considering how technology-resistance and age are often related. The way older people could benefit from the use of VR is tremendous, ranging from aspects of health diagnosis (e.g. early detection of Alzheimer's) and health and wellness treatments, to overcoming mobility restrictions by virtual travels, up to enabling communication with family members – to name just a few examples.

We are proud that Team Clarify was resilient enough to overcome many challenges during the project: Gaining access on the field under these unprecedented times, and also approaching the topic from a social science point of view – which was a new field for

them. They successfully dealt with the current state of knowledge and have gradually specified and further developed their ideas in an impressive manner on their own. They consistently managed their project in both a goal-oriented as well as a creative way: They even created VR content themselves, which is remarkable, as content creation for VR requires many skills, and is time- and resource-intensive.

In addition, the team found creative solutions to overcome social-distancing restrictions and set as a priority the health of elderly participants.

For the content creation, the team found a wonderful partner from the Bavarian XR community: Granny Vision, who are convinced that “No one is too old for something new.” The start-up by Carolina and Daniel Bendlin is driven by the idea of instilling positive emotions within older people through virtual reality. Their innovative and human-centered idea is to enable relatives to create private content in 360 degrees and transfer it to VR glasses. The grandparents can thus experience their great-grandson's first steps or the family vacation up close in VR. Carolina and Daniel explained to the team Clarify possible applications and supported them in the creation of a Munich city tour in VR. Carolina Bendlin was impressed by the team´s ideas and energy and highlighted that the team did not actually need support for the conceptual ideas of the tour since they already had a clear vision themselves.

Overall, the Clarify team managed to be agile and creative, involved people from their close environment and at the end of the day this is what is important in this project and in research in general: Bridging the gap between research and everyday life. ■

You are never too old for something new

Granny Vision GmbH is a young Munich-based company that aims to use Virtual Reality (VR) in order to provide elderly people with adventures that they can no longer experience in real life due to physical or mental limitations. Team Clarify developed its project together with the company; our collaboration primarily focused on creating a virtual tour around Munich.

The two founders Carolina and Daniel Bendlin also shared their expertise in Virtual Reality and senior citizens with us. Julia Angerer and Magdalena Bader interviewed the two of them. Thereby we were able to get some deeper insights into the world of nursing homes, seniors, city tours, forest walks and entrepreneurship.

Carolina Bendlin, the creative head of the company.

Daniel Bendlin, keeps the overview and a clear head.

Magdalena: You founded Granny Vision almost exactly two years ago. Back then, what motivated you to start a company?

Daniel: The basic idea actually came from a hospice. I was a trainee as a volunteer hospice helper here in Munich at the beginning of 2019. There, they had sixteen rooms, eight of them faced the street and eight faced the garden. When people with a room towards the street found out that a garden room had become available, they immediately wanted to move there, just to be able to look out into the green again and not only see cars during their last days. I found that very moving at the time. Simultaneously, I started to get more and more involved with VR and I also talked a lot to Caro about it. At some point we said to ourselves that we had to make something out of that. This is how our idea ultimately was born. We received a lot of positive feedback from the care sector about our project – and then we simply decided to found the company.

Caro: We also have the possibility for relatives to record their own photos and videos so that the seniors can then watch the content on our VR glasses. This also came about because I have a very close relationship with my grandma, but I'm physically far away from her. I would just like to let her participate in my life a little more. And we figured that I'm probably not the only person who feels that way.

Magdalena: Yes, that's true. But did you have any reservations when you founded the company or was it totally easy for both of you?

Caro and Daniel (both laughing): That depends on whom you ask!

Caro: Well, I'm more of a worrier and Daniel is more of a "just go for it" type.

Daniel: Yes, that's probably true. By that time, I had already accompanied a few start-ups during their founding phase, and I had also founded one by myself. So, I had lost a bit of my shyness about the whole process of starting a business. Still, Caro had some concerns in the beginning, but I think they have become smaller and smaller.

Caro: Now it's okay. (both laugh)

Julia: Basically, you have two mainstays – VR content on the one hand and your digital courses on the other. What projects are you currently working on?

Caro: VR is definitely our main focus. But it's also important that seniors and caregivers know how to use the technology, that's why we offer digital seminars as well.

Daniel: Of course, that was also a bit Covid-related. We had the digital courses ready, and many institutions were really convinced of them, but then Covid came along and that was the end of the digital courses for the time being. As a result, we started to focus more on VR.

Julia: One of your projects was our virtual city tour. Of course, we learned a lot from this collaboration – but why did you take part in our project in the first place?

Daniel: Well, you were a special project with cool components. Especially because of the regional reference, since we are a Munich company. And cooperating with TUM was also great for us, of course.

Caro: Yes, definitely. I had a lot of fun working with you guys. I hope you felt the same way! The TUM: Junge Akademie as a reference is also great for us, of course. It was another exciting project that we had a lot of fun with.

Daniel: We often let people choose for themselves what they want to view, and many of our participants want to see a city tour, especially when we visit facilities in the Munich region. That's a great thing, of course, when people recognize sights, for example. From that point of view, it's a really great project that we're also very happy to be involved in.

Julia: That makes us very happy! But before you can show seniors your VR content, you first need customer contact. How do users usually find out about your company?

Caro: It varies a lot. Sometimes via our website, via contacts, via 'Care for Innovation' ...

Daniel: ... Yes, it's really quite different. In the beginning hardly anyone knew us, and we reached out to many institutions. That has shifted a bit now, because we have a strong online presence, we are in several associations, we participate in contests, and of course we benefit from the classic word of mouth. But in the meantime, we're starting to enter the B2C business, so that people who are at home can also use Granny Vision with their loved ones.

Julia: Unfortunately, we've also had the experience that some seniors got dizzy or nauseous when using the VR glasses. You have mostly told us about positive feedback so far – have you also received any negative reactions?

Caro: Actually, we have only ever had positive feedback. We don't receive a lot of replies when we lend the glasses to facilities because the nurses work with the people there. But we would definitely be informed if dizziness, nausea or something like that occurred. Regarding this, we are in close contact with the institutions.

Daniel: But to be honest, our group of participants is also not entirely representative. You must consider that care facilities are willing and open to a certain extent if they are asking for our services. The organizations know their residents, and they know exactly who is open and willing to participate and who is not. In addition, they know that a headache or something similar is not caused by the glasses per se, but perhaps because they have been used for too long. In this case, the session will be a little shorter next time. Honestly, we have never observed headaches or nausea. Well, some people get a little dizzy, especially when they are not sitting but standing. But then, of course, we tell people to take it a little slower.

Magdalena: This means that you reach many informed and open-minded persons. We ourselves have experienced that some people are totally enthusiastic about the glasses. Do you have the feeling that participants also have a better life outside of Virtual Reality because of this experience?

Caro: Yes, definitely. That's actually the main purpose of this whole thing, that you can escape from everyday life for a short time. In addition, you get other impressions in your head again, there's just more happening around you. Especially in nursing homes, the daily routine is already pretty predefined. And this way you simply have the opportunity to get other input. So, you can actively take part in life again and you have new topics of conversation.

Daniel: I think so, too. We currently have a total of 120 or 130 different contents on the glasses. It starts with individual video or image sequences where people can be out and about and see something new. Then there are also games – people can play virtual chess for example. And the best thing is when participants start talking to each other about it because they simply have more conversation topics through VR. Another very important point is the personal content provided by relatives. If the family decides to bring their relatives in need of care back into the family circle – virtually in 360° – that is of course an insane enrichment for life.

Caro: Exactly, it is actually a product that does a lot with your emotions, regardless of whether your own family is involved or not. And, of course, you carry that beyond the point where you take the glasses off again.

Magdalena: So, the whole project has a very big emotional and social component. But you probably want to pursue your goal of improving self-confidence in dealing with technology in the long term. Do you have any plans for if and how Granny Vision might change in the future?

Caro: In addition to nursing, we are expanding our circles into the private sector, so we are rather getting out of an organized environment. But we always said from the beginning: Who knows where we will end up or how we will develop? But considering the way it has played out over the last two years, it's definitely VR that we will keep our focus on.

Daniel: So, ultimately, Virtual Reality for seniors. That's what Granny Vision already is and that is what it is going to remain.

Magdalena: That means that you are not planning to introduce another new technology either?

Daniel: No, because we really believe that Virtual Reality has a very promising future. If you just look at the last two years, there are huge leaps in what has been happening in terms of technology. And that will continue. And that's why we want to stay with it.

Julia: Well, thank you very much for your time. Not only today for the interview, but also for the fact that you participated in our project and that you were just as enthusiastic as we were! ■

Clarify

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Abstract

New technologies such as Virtual Reality can be very beneficial to elderly people. Scarce research exists with regards to the adoption of such technologies by older adults. In this study, we applied the Unified Theory of Acceptance and Use of Technology to identify predictors of future VR usage intentions. 72 participants aged 60 to 91 years were recruited for our work. Subjects took part in a VR tour through Munich, Germany, and filled out a questionnaire established in prior research.

48 % of our participants intended to use VR in the future and 76 % enjoyed using the technology. Previous Smart Phone Usage was not shown to predict Intention to Use. The factors Perceived Usefulness, Social Norms as well as Age and Gender were demonstrated to significantly influence the Intention to Use VR and increased age was negatively related to technology acceptance.

The results of this study support the notion that Perceived Usefulness and Social Norms predict technology acceptance. Close attention should be paid to perceptions of usefulness, encouragement by significant others and age when addressing groups of older adults.

Abbreviations

Abbreviation	Meaning
H	Hypothesis
IU	Intention to Use
PE	Perceived Enjoyment
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
SN	Social Norms
TAM	Technology Acceptance Model
UE	User Experience
UTAUT	Unified Theory of Acceptance and Use of Technology
VR	Virtual Reality

Introduction

New technologies have many positive effects for the elderly. Virtual Reality (VR), for example, is a technology that is offering realistic experiences in controlled areas with low or no risk. Senior citizens can use it in the comfort and safety of their own homes and can be transferred to new realities. It is an enjoyable, innovative tool that can advance the recollection and retention of the memory as stated by the Virtual Reality Society. According to a Cambridge study (Lin et al., 2018), it has been shown that experiencing and using VR glasses can decrease the risk of depression and the feeling of loneliness among the elderly. This technology seems to have positive effects in the majority of the study's participants, as they appeared to feel more outgoing and less stressed or isolated.

Moreover, latest statistics of 2018 have demonstrated that 78 % of the German population have heard about VR (Statista, 2020) and a growing number of seniors try out the internet, smart phones and video games (C.Gaspar, n.d.). Computer usage in general has been shown to positively affect information processing, reading, comprehension, and the memory in a positive way, resulting in a faster reaction time and an increase in attention span and hand-eye coordination of the elderly (Oppenauer, 2009). Virtual Reality usage appears to have potential benefits in a variety of health indicators, although research is still inconclusive (Miller et al., 2014). Despite the positive effects and the importance of modern technologies for the elderly, there has been insufficient research on its adoption by older adults. The focus of attention has traditionally been placed on the implementation of e-communication tools for elderly patients in primary care or on software solutions specially designed to fit the needs of elderly users. There is, however, scarce research about the extent to which the elderly, especially in Germany, accept or use new technologies such as Virtual Reality. Motivating this target group to apply VR glasses could increase their enthusiasm and their intention to also use other potentially advantageous technologies. As a result, one would expect acknowledgment of positive effects by the elderly and thus the acceptance of digital technologies.

A related research study (Syed-Abdul et al., 2019) on a group of 30 elderly people aged 60 to 95 years in Taiwan found that Perceived Usefulness, Perceived Ease of Use, Social Norms and Perceived Enjoyment significantly affect the Intention to Use Virtual Reality. Furthermore, participants mostly agreed about Perceived Enjoyment, Perceived Usefulness and their experience of applying VR. It was concluded that this technology is highly accepted among the elderly population.

George Coldham and David M. Cook found a difference between answers on the pre- and post-questionnaires given during their experiment. 63 % of the participants stated that they did not really expect to use VR for anything useful and 79 % held the view that this tool is a frivolous undertaking that provides little benefit. However, after completing the VR exercises, many participants confessed that they could begin to understand the possible usefulness of Virtual Reality. Also, 42 % expressed a "wow" factor once they had applied VR glasses (Coldham & Cook, 2017).

Theoretical Background: Technology Acceptance Model

In efforts to provide an integrated model that can be used to explain information technology adoption, the Technology Acceptance Model (TAM) was proposed (Davis, 1989). This framework has later been validated in empirical work and it is believed to explain technology acceptance as well as actual usage of various technological systems (Venkatesh, Thong, & Xu, 2012). The attitude of people towards using a certain technology depends on the so called "Perceived Usefulness" (PU) and the "Perceived Ease of Use" (PEOU) in addition to other salient factors added into subsequent iterations such as "Perceived Enjoyment" (PE) and "Social Norms" (SN). Those aspects are then hypothesized to predict a user's intention to utilize the technology under consideration.

The Technology Acceptance Model was employed by several researchers over the years since its conception with uses ranging from education and learning (Chao, 2019) to organizational behavior and leadership research (Neufeld, Dong, & Higgins, 2007).

The model has also been applied to predict technology adoption in different contexts and across a variety of modalities such as health information technology or smart phone and computer usage (Venkatesh et al., 2012). Nevertheless, TAM lends itself to extension and adaptation to a variety of population groups, which helps researchers to identify the relevance of certain constructs for a specific target group.

The TAM has further been extended to include external determinants of acceptance such as education, health, and psychological needs (Oppenauer, 2009). The model was then specifically adapted to Virtual Reality hardware (Manis & Choi, 2019). A pilot study conducted with older adults and VR glasses in Taiwan added the user experience variable "Interactivity" to the framework, which was found to be associated with behavioral intentions. Current efforts lie in further understanding the influence of User Experience variables (UE) on Intention to Use VR (IU) and how these interact with well-understood variables such as Perceived Ease of Use (PEOU) and Perceived Usefulness (PU).

Although technology acceptance in older adults has been studied in healthcare contexts with usages such as m-health (Hoque & Sorwar, 2017), research with regards to the adoption of VR is still scarce (Syed-Abdul et al., 2019). Furthermore, the demand to expand the theoretical mechanisms underlying UTAUT and adapting them to newer contexts still exists in line with the need to improve the generalizability of the theory which has been highlighted by several authors (Bagozzi, 2007; Venkatesh et al., 2012). In our research project, we aim to use the TAM in a similar fashion. We applied newer iterations of the model to a sample of older adults that integrates relevant variables based on prior research, with the focus on determining the influence of those constructs on Intention to Use (IU), a measure of overall VR technology acceptance. We further intend to identify salient factors in our target group by adding aspects such as previous smart phone usage, paving the way for the development of newer framework iterations adapted to VR acceptance in senior citizens.

In the first part of this work, we describe the methods we used to measure technology acceptance by assessing the relevant constructs and using Intention to Use (IU) as a proxy for overall acceptance levels. Next, we briefly move to the analysis of our results and explain the insights we got from the evaluation of our questionnaires. Finally, we sum up our research on this topic and provide recommendations to producers, practitioners and clinicians who would like to offer VR tools to seniors and to whom predictors of usage intentions will be especially useful.

Goals and Methods

Goals

Our main goals were to expose senior citizens to new technologies and offer an enjoyable experience with devices that are expected to see increased demand in the future. An additional aim was to provide the elderly with relief from the isolating circumstances people experienced during the COVID-19 pandemic. Measuring overall enjoyment was thus also a focus of our project.

The aim of our research study was to investigate the acceptance of VR technologies in older adults and to determine important predictors (through Intention to Use, IU) by applying the framework UTAUT (Unified Theory of Acceptance and Use of Technology, see Figure 4). In our study we tested the hypothesis of the model and added three additional variables, namely Age, Gender and previous Smart Phone Usage. All factors were tested for associations with Intention to Use the technology in addition to the interrelations asserted by the framework. In UTAUT, Intention to Use acts as a proxy for the degree of acceptance as well as strength of motivation and was an important predictor of adoption behavior in prior research work (Venkatesh et al., 2012). We replicated and extended a model resting on a previous study (Syed-Abdul et al. 2019) which proposes the following relationships:

- H1: Perceived usefulness influences the intention to use VR.
- H2: Perceived ease of use influences the intention to use VR.

- H3: Perceived ease of use influences the perceived usefulness of VR.
- H4: Social norms influence the intention to use VR.
- H5: Perceived enjoyment influences the intention to use VR.
- H6: User experience has an effect on perceived usefulness of VR.
- H7: User experience has an effect on the perceived ease of use of VR.

We further propose three hypotheses:
- H8: Age influences the intention to use VR.
- H9: Gender influences the intention to use VR.
- H10: Smart phone usage influences the intention to use VR.

Study Design and Participants

Study Design

72 participants were recruited for our study, through the TUM: Junge Akademie network as well as through common friends and advertisements on our website. Subjects were sent VR glasses and given time to use the devices, take part in our VR tour and fill out a questionnaire. Later, as restrictions due to the COVID-19 pandemic were eased, our team also visited elderly care centres, namely ASZ Sendling and ASZ Moosach of AWO Munich, and showed the VR tour to visitors who met our inclusion criteria.

VR Tour

Our VR tour was approximately ten minutes long and showed 360° visual images of Munich as well as auditory voice-overs explaining the relevance of specific sights. The tour included the areas Marienplatz, Odeonsplatz, Hofgarten, Olympiapark, the Thiersch-Turm and the TUM main campus amongst others.

Questionnaire and Translation

The questionnaire consisted of seventeen items measuring the constructs Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Social Norms (SN) and Intention to Use (IU) as well as additional factors such as prior Smart Phone Usage, Age Group and Gender of participants. Question items were based on a provided questionnaire (Syed-Abdul et al., 2019) and were translated from the English language to German by our team. The German translation was then sent to professional translators, as well as native English speakers for a translation back to English. The English questionnaire derived from our German version was then checked for deviance from the original and deemed appropriate by all members of the team.

Statistical Analysis

Statistical analysis was performed using the software JASP (Love et al., 2019). Normality of data was checked applying the Shapiro Wilks test.

Mean response scores, ranging from 1 (completely disagree) to 5 (completely agree) for each construct, were calculated by the software and utilized for subsequent analysis. Reliability of the questionnaire was calculated using Cronbach's Alpha.

Based on the methodology applied by previous authors, simple linear regression was performed for each of the factors Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Perceived Enjoyment (PE), Social Norms (SN) as well as Smart Phone Usage, Gender and Age as independent variables with Intention to Use (IU) as the dependent variable to test the hypotheses described before and which are illustrated in the figure below (see Figure 4). In the case of valid assumptions, a subsequent multiple linear regression was performed using a backward-entry method and the model with the highest fit was chosen.

The degree of acceptance (overall Intention to Use, IU) and overall enjoyment scores (Perceived Enjoyment, PE) were also calculated, displayed in charts and stratified by previous Smart Phone Usage.

Results

Sample Description

72 subjects (n = 62 female; n = 10 male) were recruited for our study and fulfilled the inclusion criteria. The age of our participants ranged from 60 to 91 years. The characteristics of the sample stratified by age groups are shown in Table 1.

Age	60-65	66-70	71-75	76-80	81-85	86-90	91+
Number	5	4	10	46	3	3	1

Table 1: Number of participants stratified by age group.

Descriptive Statistics

The mean score for each of the variables Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Perceived Enjoyment (PE), Social Norms (SN), User Experience (UE) and Intention to Use (IU) as well as their standard deviations are displayed in Table 2. Scores ranged from 1 (completely disagree) to 5 (completely agree).

	PU	PEOU	PE	SN	UE	IU
Mean	2.00	4.46	4.37	1.77	3.84	2.15
Standard deviation	1.27	1.15	1.08	1.13	0.78	1.22
Minimum score	1	1	1	1	1	1
Maximum score	5	5	5	5	5	5

Table 2: Mean score, standard deviation as well as minimum and maximum score for each of the six examined factors proposed by UTAUT.

The percentage scores for each of the variables were calculated and are presented in Figure 1.

- 46 % of subjects thought that VR was useful in their daily life.
- 80 % thought VR was easy to use.
- 76 % thought VR was enjoyable.
- 28 % were encouraged by significant others to use the technology.
- 78 % thought the user experience was user-friendly.
- 48 % agreed that they intended to use the technology in the future.

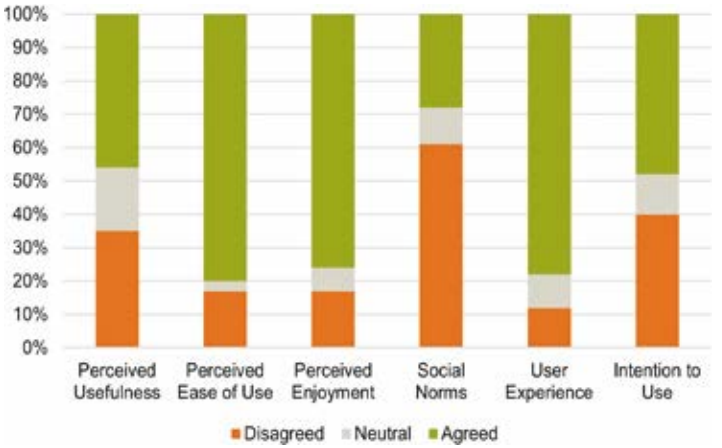

Figure 1: Summary of the responses by the participants in terms of percentage.

The scores for Intention to Use (IU) and Perceived Enjoyment (PE) are also displayed stratified by previous Smart Phone Usage in the box plots of Figure 2 and Figure 3, with the median values made visible through the lines within the plots.

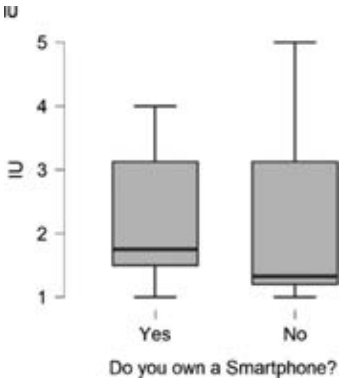

Figure 2: Score for Intention to Use (IU) VR technology stratified by previous Smart Phone Usage.

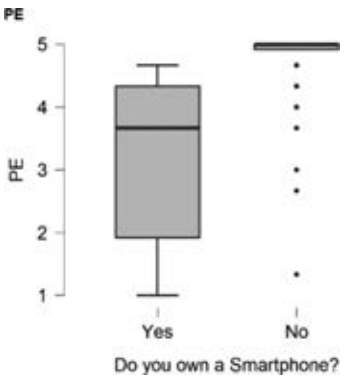

Figure 3: Score for Perceived Enjoyment (PE) of VR technology stratified by previous Smart Phone Usage.

Regression Results

Perceived Usefulness (ß = 0.832, p < 0.001) and Social Norms (ß = 0.730, p < 0.001) were shown to significantly predict the Intention to Use VR technology. User Experience influences Perceived Usefulness (ß = 0.640, p < 0.001) and it also influences Perceived Ease of Use (ß = 0.333, p = 0.004).

Perceived Ease of Use was not shown to influence Intention to Use (ß = -0.092, p = 0.442) and the factor also does not influence Perceived Usefulness (ß = -0.181, p = 0.128) in our sample. Perceived Enjoyment (ß = -0.050, p = 0.677) does not influence the Intention to Use VR.

Age (ß = -0.485; p < 0.001) and Gender (ß = 0.350; p = 0.003) significantly predict the Intention to Use VR. Smart Phone Usage does not influence Intention to Use (ß = 0.032; p = 0.788), but it predicts Perceived Enjoyment (ß = 0.587; p < 0.001).

The variable ß describes the coefficient of the respective regression model, meaning that for every increase in the independent variable (e.g. PU, PE) the dependent variable experiences an increase of ß units. The variable p signifies the p-value, whereby a value below 0.050 represents a statistically significant result. The results of our regression model are displayed in Figure 4.

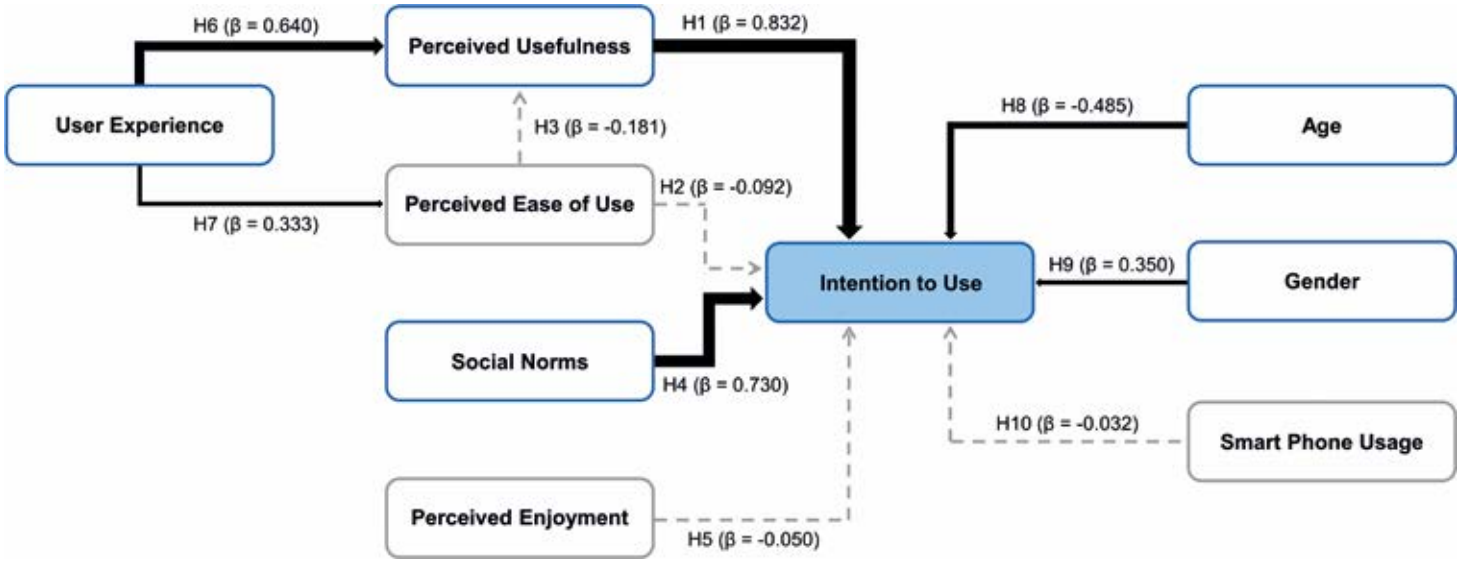

Figure 4: Results of the regression model. Lines represent significant influence of variables on Intention to Use (p < 0.050). Dotted lines signify lack of significant influence of a factor. Thickness of line represents strength of influence.

Our data did not violate the assumptions for multi-colinearity, and we were thus able to apply a multiple regression model using a backward-entry method in addition to the statistical methods described above.

After adjusting our regression analysis and choosing the model with the highest fit, only Perceived Usefulness (ß = 0.395; p = 0.003), Social Norms (ß = 0.255; p = 0.008) and Age (ß = 0.242; p = 0.041) were shown to influence the Intention to Use VR, a result similar to the one found in our simple regression models.

Discussion

Interpretation of Our Results

While overall levels of enjoyment were relatively high (76 %), Intention to Use Virtual Reality was moderate with only 48 % of users indicating that they would like to work with the technology in the future, which we used as a measure for overall acceptance of VR. It is thus important to further analyze the determinants of technology acceptance in our sample. The results suggest a significant influence of the constructs Perceived Usefulness (PU) and Social Norms (SN) on the Intention to Use (IU) VR technology in a sample of older adults and particularly stable effects of Perceived Usefulness (PU), Age and Social Norms (SN).

Perceived Usefulness (PU) consists of perceptions of utility such as in daily activities, meaning that subjects were able to imagine using the technology in their daily life, and for facilitating the completion of tasks. This notion is also supported in the literature at large and was postulated to be an important predictor for the acceptance of various technologies in the original model (Venkatesh et al., 2012) as well as in previous studies of VR (Syed-Abdul et al., 2019). In the present work, Perceived Usefulness was the most important factor in predicting Intention to Use VR.

Perceived Enjoyment (PE) refers to positive emotions related to technology usage, sometimes referred to as hedonic motivation (Venkatesh et al., 2012). This factor was added in subsequent iterations to the model, and it aims to measure the pleasurable aspects of technology utilization. The effect of enjoyment is not supported by our research in older adults and should receive more attention, as we did not find a significant relationship of PE with Intention to Use, while overall enjoyment levels were very high. This is especially important since Perceived Enjoyment was not included in the original model (Davis, 1989) and was sometimes seen as related to Perceived Ease of Use (PEOU). Moreover, User Experience (UE), the degree to which the user interface was perceived as user-friendly, influences both Perceived Ease of Use and Perceived Usefulness (PU). This demonstrates that manipulations of the User Experience can significantly impact the Perceived Usefulness of VR and thus the Intention to Use is independent of its actual usage in performing important tasks.

Social Norms (SN) measures the extent to which significant others such as family members and friends encouraged our participants to use the technology, and this too was found to influence usage intentions in our research. These results support findings in the literature where Social Norms predicted the acceptance of several forms of technologies in a variety of samples (Yau, H. K., & Ho, T. C., 2015). Social ties were specifically shown to impact acceptance of VR in a similar line of research using the TAM model (Lee, Kim, & Choi, 2019), and it was also demonstrated that social perception was heavily influenced by Perceived Enjoyment (PE).

While Perceived Ease of Use (PEOU), the extent to which subjects did not experience difficulties with using the technology, is an important factor in the Technology Acceptance Model (Venkatesh et al., 2012) and was seen to determine acceptance of technologies

across studies, its relevance was not shown in the present work. Similar results were also observed by others (Sagnier, Loup-Escande, Lourdeaux, Thouvenin, & Valléry, 2020), where no significant influence of Perceived Ease of Use in the acceptance of VR technology was found. This could in part be due to the characteristics of our sample, but also due to the nature of Virtual Reality technology, where most subjects would indeed expect such novel technologies to be difficult to operate and which could have caused them to adapt their expectations. However, more research is needed to determine the role of ease of use among modern technologies such as VR and its relationship to Perceived Enjoyment (PE).

Age and Gender were shown to predict the Intention to Use VR. This assumption is supported by our data, with a negative coefficient for the factor Age, suggesting lower usage intentions among older participants. Longitudinal studies of technology acceptance in older adults, using TAM in a healthcare context, have shown that age influences relevant study outcomes, which is mainly due to the cognitive demands of the technology and psychomotor difficulties related to actual system use (Murugesh-Warren et al., 2015). These mechanisms likely influenced our target group and may be related to the low Perceived Usefulness (PU) of the technology. Research comparing generational effects on technology acceptance has shown that determinants such as effort expectancy may themselves play a substantial role, especially in samples of older adults (Magsamen-Conrad, Upadhyaya, Joa, & Dowd, 2015). Indeed, the influence of effort expectancy may help to explain the missing effects of Perceived Ease of Use (PEOU) and Perceived Enjoyment (PE) in our study. Future research should thus focus on identifying the mechanisms underlying age-related challenges and provide solutions to remedy a possible sense of apprehension. The effect of Gender may also be attributed to Age, as most of our sample was primarily composed of female participants (see sample description). Gender has been largely regarded as a moderator in prior research (Khechine, Lakhal, Pascot, & Bytha, 2014), but it is unclear if it has affected the results of our study independently of the characteristics of our sample.

We further hypothesized that Smart Phone Usage, a factor we applied as a surrogate for prior experience with technology, would influence technology acceptance. Despite our assumptions, Smart Phone Usage did not significantly influence usage intentions in our sample. This indicates that prior experience with modern technologies such as smart phones is not a prerequisite for the acceptance of VR.

Special attention should be paid to Age, Social Norms (SN) and Perceived Usefulness (PU) which, in addition to exhibiting the highest predictive values, were also shown to predict Intention to Use (IU) in our multiple regression model where we have also accounted for the influence of other salient factors.

Limitations

Our study was performed with a large sample of older adults, but due to the pandemic, the number of participants in the age ranges 60 to 70 and 81+ was relatively small. We also have yet to calculate interrelations and thus indirect effects between the factors using structural equation modelling. This study measured the usage intentions of our participants and although these are associated with actual usage, intentions are typically not a perfect predictor of behavior due to the “intention action gap” (Sheeran & Webb, 2016). Future research should investigate VR acceptance in older adults applying a long-term approach to ensure usage intention did translate into future behavior. Researchers could also identify the role of Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) using longer time frames to create situations where the technology could be applied to facilitate daily activities.

Summary and Future Goals

Acceptance of VR is moderate, with 48 % of our sample intending to use the technology in the future, and although enjoyment levels are high, the variable enjoyment itself does not predict users' behavioral intention to apply the technology hereafter. Practitioners and clinicians that intend to utilize the glasses in samples of older adults should think of ways in which VR could improve activities of daily living and be perceived as useful. They can also emphasize its utility for future users by improving the User Experience to increase perceptions of usefulness irrespective of the practical applications, as there is a direct and significant path between User Experience variables such as user-friendliness and the Perceived Usefulness of the technology. Acceptance will also be affected if significant others such as family members, peers and friends support the user's adoption of such devices. Although Perceived Ease of Use and Perceived Enjoyment are important factors in technology acceptance overall, their roles appear to be overestimated with regards to VR. Prior experience with technology such as Smart Phone Usage does not impact the Intention to Use VR and is thus not a requisite factor for its acceptance. Future research should focus on explaining age-related declines in technology acceptance and identify reasons for the absent effects of Perceived Enjoyment and Perceived Ease of Use in our study, perhaps adjusting VR-related adaptations of the Technology Acceptance Model.

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Self-reflection

We are now looking back at twenty-three months of an active scholarship program at the TUM: Junge Akademie and being part of Team Clarify. Back in 2019, we started our journey as a team of six students enrolled in diverse fields of study: Brewing & Beverage Technology, Engineering Science, Health Sciences, Industrial Biotechnology, Informatics and Mechanical Engineering. This interdisciplinary environment always helped us to find innovative solutions to very diverse questions that emerged along the way and encouraged us to view problems from different perspectives.

What definitely brought us together at the Kick-off event at Lake Kochel was our initial project idea about science communication and working with children or young adults on common misunderstandings. We started from a joint observation: engagement with and openness towards science and modern technologies is not distributed equally among different groups of citizens in Germany. Our start, however, was a bit bumpy, because we all came up with a lot of diverse, very promising ideas and often shifted between decisions. Maybe we were just a bit overwhelmed by the project itself and all the possibilities that the TUM: Junge Akademie offered us.

During exhaustive research at the very beginning of our project work, we discovered that a lot of studies already dealt with our desired target group. This finding was a huge setback, but we did not hesitate for long and started considered investigating the elderly population instead. Even though some team members were not happy with this shift in our topic, every one of us realized that identifying a research gap was essential for the success of our project. Over time we noticed that understanding technology acceptance in older adults is vital in making the most out of its potential applications and now, at the end of our work, everyone is very happy about the chosen target group. Another issue we had to deal with was the question of how to integrate an artistic component into our project, since our call “Technology & Arts” had to be taken into account as well. Therefore, the idea came up to utilize art as a medium to inform elderly citizens about technology, for example by producing an entertaining video.

Mrs. Schmidt, who supported our work as one of our supervisors, gave us a reference to Granny Vision GmbH in the very early stages of our project. This hint helped us a lot because we were able to establish a cooperation with them, which changed our topic completely. Thanks to our partner company, who is working in the field of providing VR for senior citizens, we found a common ground for our project that every member was very excited about, and we were able to clarify our final research question: Which factors influence technology acceptance in older adults? From that moment on, we had a clear vision about our topic, a goal every member wanted to achieve and a strong partner that assisted us in executing our project.

Unfortunately, by that time, the Corona crisis had come along, and reaching our target group by visiting elderly homes in and around Munich seemed impossible, because senior citizens are the most endangered group of people for a severe disease progression. We even tried to get in contact with some facilities via the phone, but the conversation ended as soon as we mentioned that we would like to talk to the residents to conduct research. One point we learned during that phase is that solving problems and not giving up when obstacles arise is essential to accomplish a project. So, we modified our procedure and decided to contact the network of the TUM: Junge Akademie to acquire participants to whom we

could show our VR tour. It turned out that in this way, we were even able to provide relatives and grandparents of scholarship holders with some fun during the hard times of the pandemic and to take them on a virtual adventure. We all found that a very nice side effect of our project!

All in all, we are grateful that our team was able to work together in such a productive way. Every member finished his or her tasks very reliably, and we always found an acceptable compromise if someone had a different opinion about a certain topic. Important points that all of us have learned during the last twenty-four months are how to express problems and opinions clearly and concisely and how to improve time management and become more efficient. This is also linked to very positive and essential aspects of our teamwork: Communication is key! And agendas are very useful! We always respected each other, were understanding and empathetic and every member was intrinsically motivated to bring our project to successful completion. Of course, we could have defined our exact topic a bit earlier, which would have given us more time to concentrate on the execution of the project. Also, deadlines shifted a lot during our work. But in the end, we always reached our goals, and we never had substantial doubt about that point.

Acknowledgments

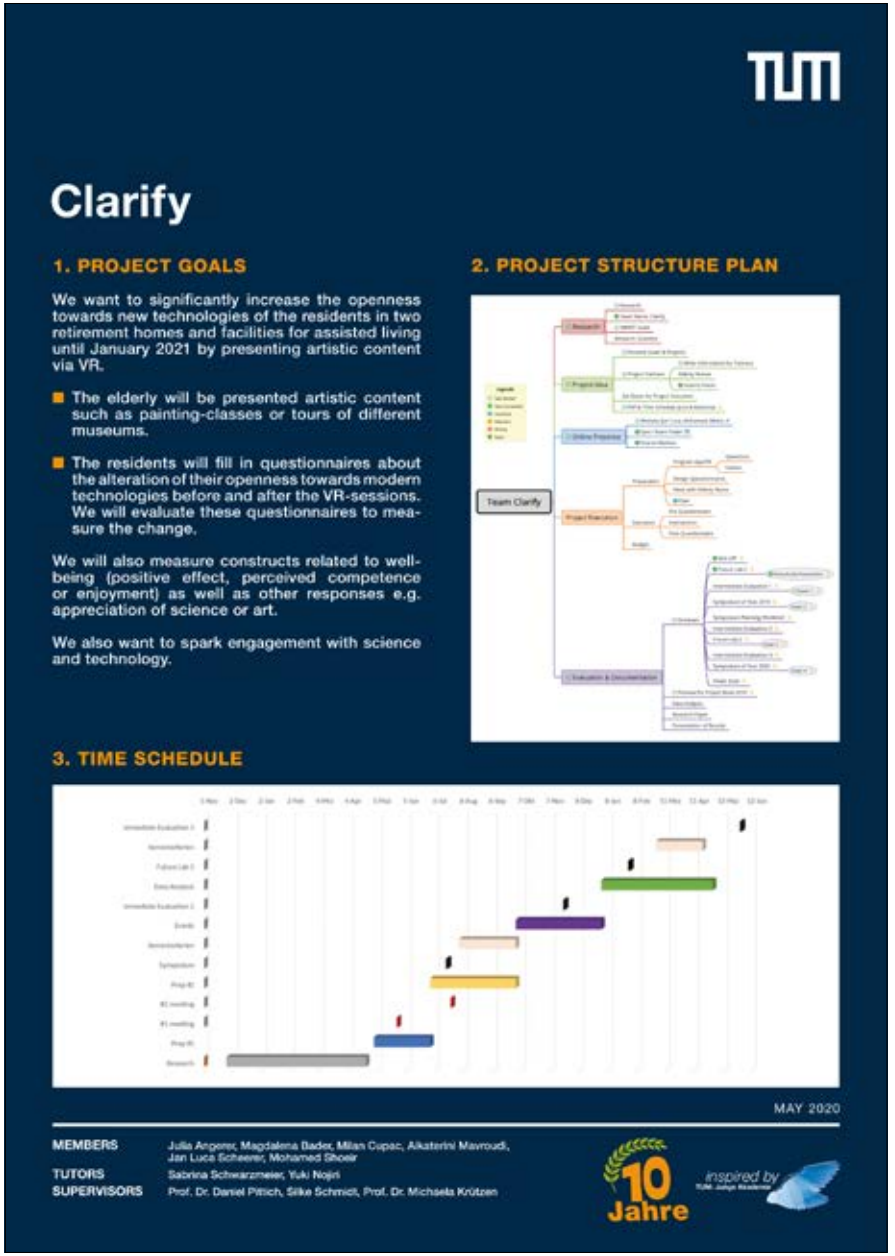
A very special thank you goes to our tutors, Sabrina and Yuki, who gave us a lot of freedom and who were always there to help us if we were really stuck on something. You answered all our questions at any time – regardless of whether they referred to our project or we just needed some general information. And you even attended our team-building events! We would also like to acknowledge our supervisors, Prof. Dr. Pittich and Mrs. Schmidt. Your input, although (or precisely because) it was critical at times, pushed us to improve the scientific basis of our research, and you always gave experienced advice and feedback when we asked for it.

We say thank you to every participant of our study and we hope you enjoyed our virtual tour around Munich. This was only achievable due to the scholarship holders of the TUM: Junge Akademie who brought us into contact with their relatives, and the ASZ Sendling and Moosach of AWO Munich that added our project to their program for senior citizens.

Thanks a lot to our partner company Granny Vision GmbH. All of this would not have been possible without you. Thank you for the collaboration!

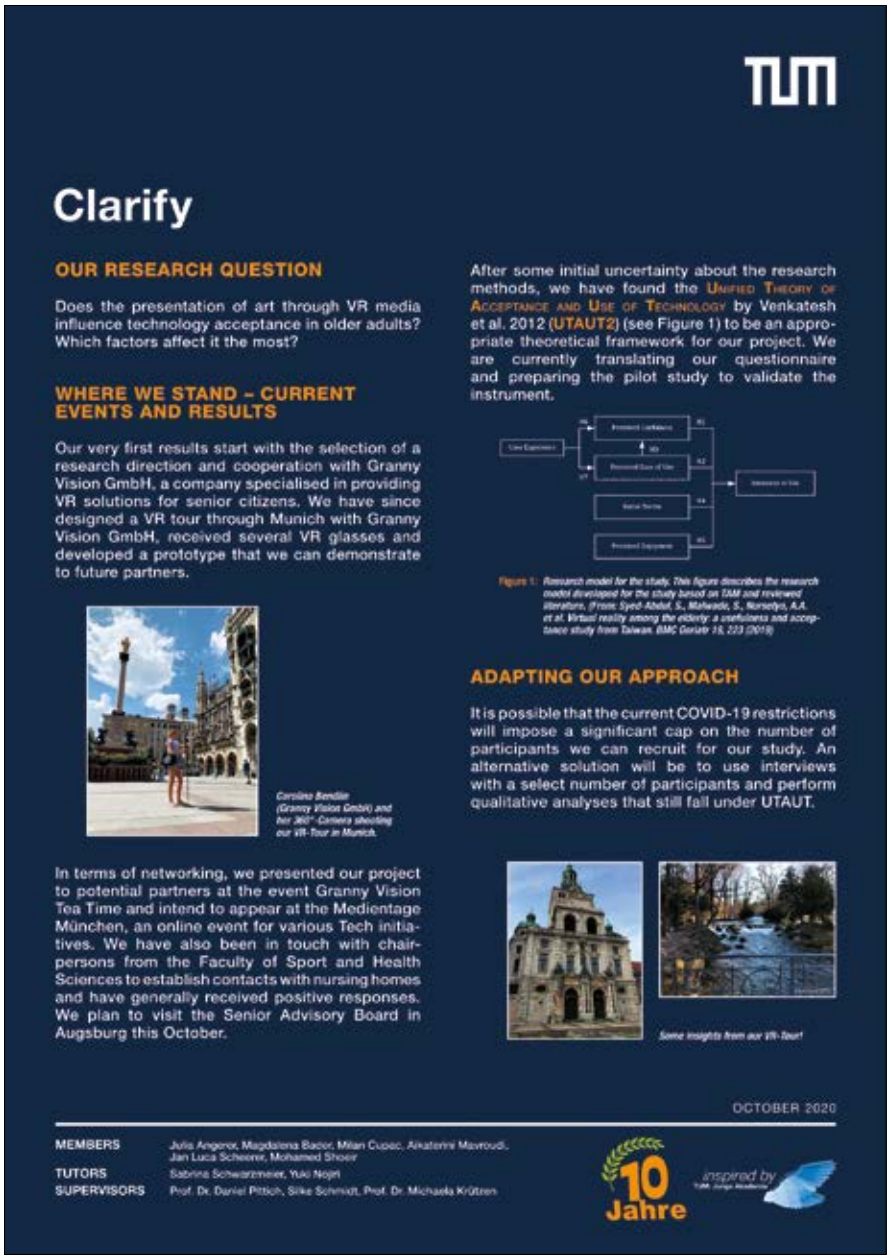
Thanks also to Christoph Reitzle who supported us in taking 360° pictures from the Thiersch tower for our VR tour. We and all our participants had a marvellous view over Munich from TUM's most famous landmark. In addition, we want to thank the TUM Sprachenzentrum, Annalena Huber, Samuel Valenzuela and Robert Kurth for back-translating our questionnaire to English. This was a very crucial step in the scientifically substantiated execution of our research.

Last but not least, we would like to express deep gratitude to the whole team of the TUM: Junge Akademie, especially to Prof. Dr. Gerhard Müller and to Peter Finger, who gave us the unique opportunity to be a part of this extraordinary scholarship program. Thank you!



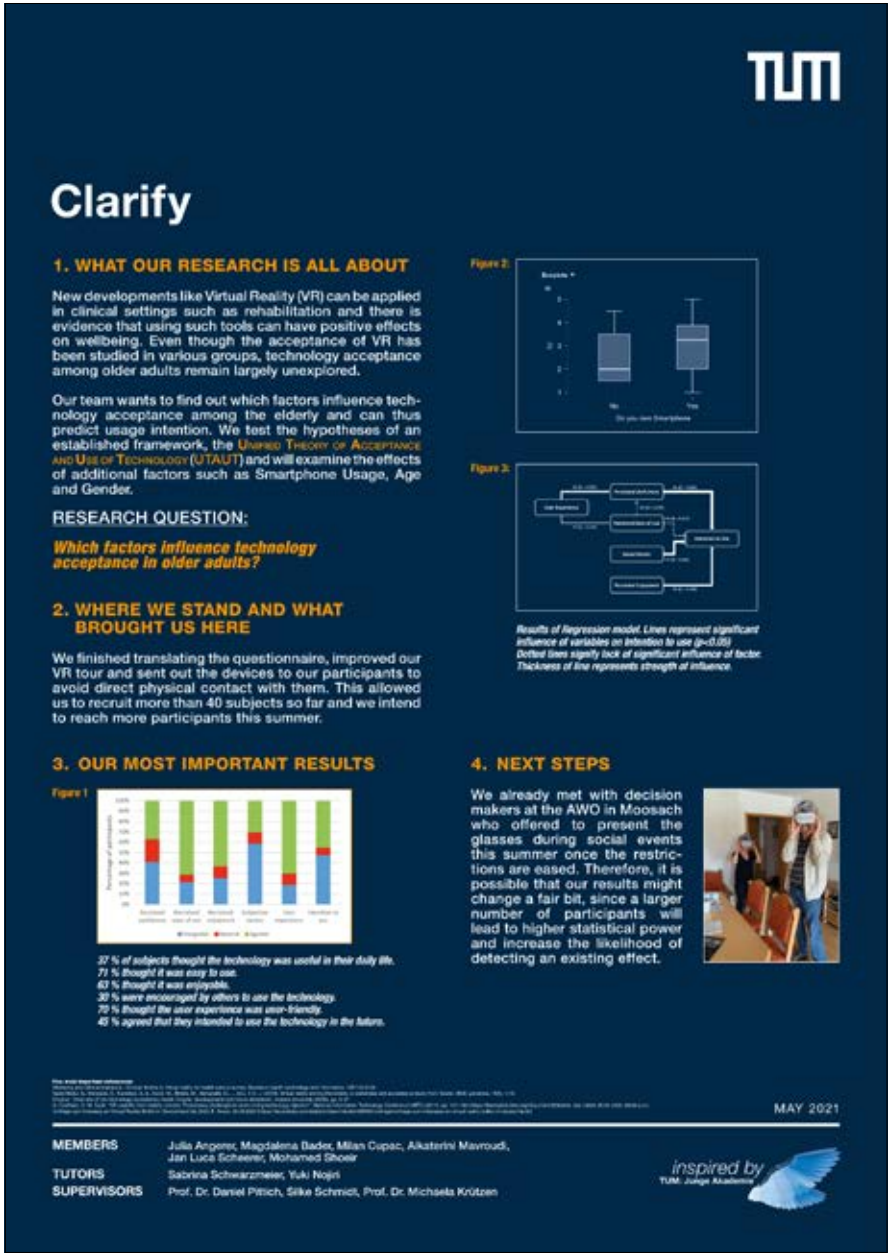
POSTER 1:

Our first poster presents the initial goals of our project “Clarify”, the project structure plan (PSP) we had framed at this early stage of our work, and a time schedule resulting from that agenda. The overall idea of our study was to integrate art or artistic content into the very exciting research field of “Science Communication” to spark engagement with science and new technological approaches. In May 2020, we had already decided on our target group and on the technological instrument we would like to utilize in our project. Since we observed that in this scientific area, children and younger adults are an already closely investigated audience, we were able to identify a research gap in the relative lack of attention to the elderly. We wanted to reach this rather heterogeneous group of people by visiting retirement homes in and around Munich between October and December 2020. During these meetings, our plan was to present different forms of art through Virtual Reality (VR) to increase the participants’ openness towards modern technologies. The virtual content was not clearly defined at this time, but we considered formats like videos, paintings, poems, or photos and thought about interactive approaches as well. To measure the impact of our project among our target group, we took the research method of questionnaires into account, which would be filled out by the participants before and after the intervention.



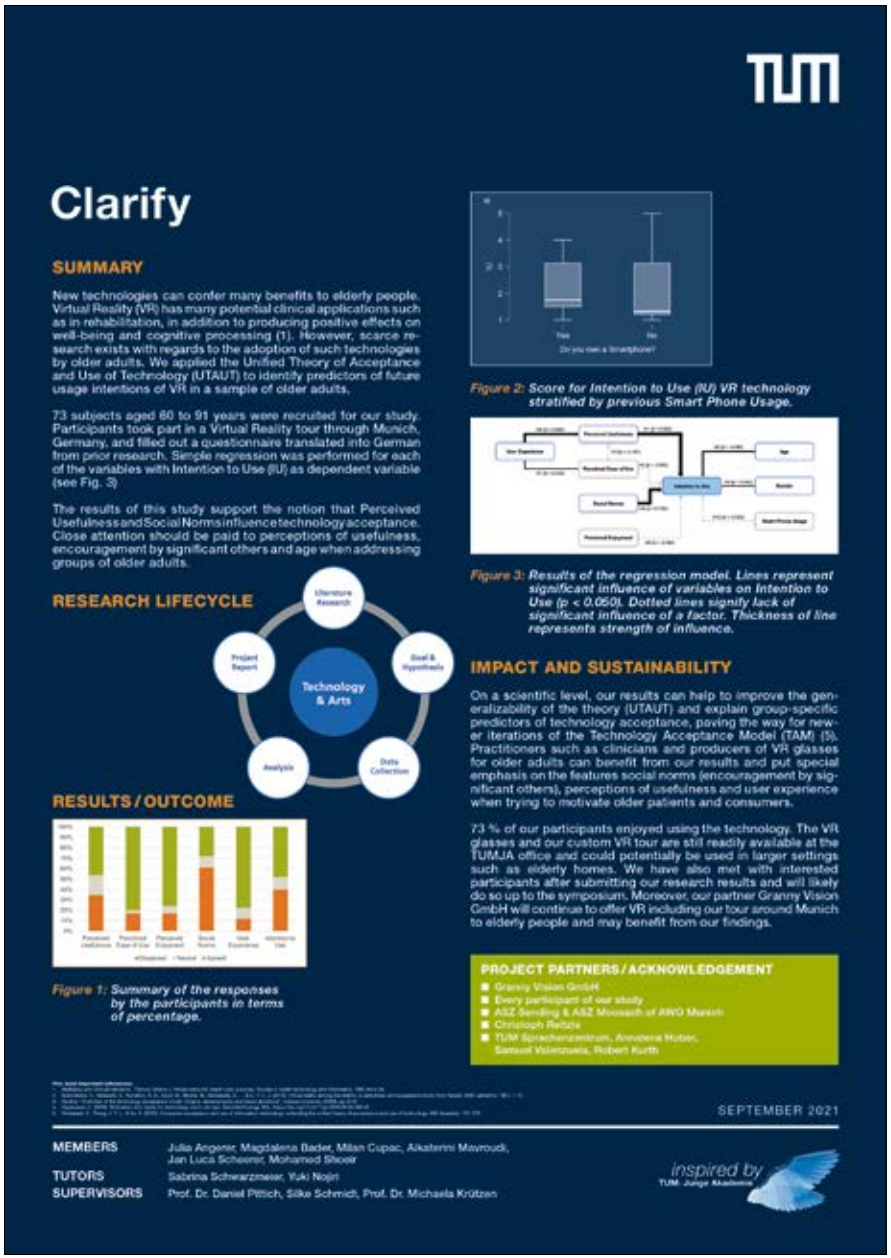
POSTER 2:

The second poster, which was released five months after the first one, presents our latest results at this stage of our work as well as our research question: Does the presentation of art through VR media influence technology acceptance in older adults? To ensure the technically correct implementation of our project, we cooperated with Granny Vision GmbH, a company specialized in providing Virtual Reality solutions for senior citizens. Together, we prepared a VR tour through Munich by taking 360° pictures of the most famous and lovely places of the city that would serve as the artistic content for our events. Furthermore, we recorded audio tracks to intensify the Virtual Reality experience that would be displayed on the seven VR glasses we received. Due to the ongoing Corona pandemic, we kept in mind that reaching our target group could be difficult during the next few months, since elderly people belong to a high-risk group in relation to the disease. Nevertheless, we did not want to change the audience which our project was aimed at, because we saw great potential in our approach. In terms of the research method, we identified the *Unified Theory of Acceptance and Use of Technology 2* (UTAUT2) as an appropriate theoretical framework for reaching our defined goals, because this *Technology Acceptance Model* (TAM) aims to explain the intentions to use technology and the subsequent usage behavior.



POSTER 3:

In May 2021, we were able to present our third poster, which already includes primary results from our research. By that time, the content for our VR glasses had been finalized and we were ready to show our virtual city tour to senior citizens. Due to the ongoing Corona pandemic, it was impossible to visit residents in elderly care homes, which was our initial means of recruiting participants for our study. Nevertheless, we succeeded in circumventing this hurdle by reaching out to the network of the TUM: Junge Akademie and lending the glasses to active scholarship holders who then introduced their families and friends to the VR technology. Using the information we received from these first 40 subjects, we were already able to test our theoretical framework and familiarize ourselves with the evaluation of the generated data. The most striking results we saw were the facts that 71 % of the elderly thought the VR glasses were easy to use and 63 % found it enjoyable, demonstrating that nobody is too old for trying out a new technology. We were also able to show that Perceived Usefulness, Social Norms and Perceived Enjoyment significantly influence the Intention to Use VR among our participants. This provides an important insight into factors that should be considered when inventing technology specially designed for the use by elderly people. As a next step, we aimed to reach more participants during the summer, hoping to increase the statistical power of our research model.



POSTER 4:

At the Symposium in October 2021, we finally presented our fourth poster including the concrete outcome of our study, a graphic visualization of our research life cycle as well as project partners and stakeholders. During the summer, when the restrictions due to the Corona pandemic were eased, we were able to acquire about 30 additional participants for our work, resulting in 72 subjects in total. We reached this goal by visiting two elderly care centres, namely ASZ Sending and ASZ Moosach of AWO Munich, showing our VR tour to a diverse group of elderly people outside of the TUM: Junge Akademie network. After evaluating our results, we found that the aspects Perceived Usefulness, Social Norms, Age and Gender have a significant impact on the Intention to Use VR technology in our sample. In contrast to that, prior experience with technology such as Smart Phone Usage does not influence the Intention to Use VR and is thus not a requisite factor for its acceptance. As a recommendation for practice, practitioners and clinicians who intend to utilize the glasses among older adults should think of ways in which VR could improve activities of daily living and be perceived as useful. They can also emphasize its utility by improving the user experience to increase perceptions of usefulness irrespective of the practical applications, as there is a direct and significant path between user experience variables and the perceived usefulness of the technology. ■