Supporting Patients and Therapists in Virtual Reality Exposure Therapy

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Abstract

This thesis explores challenges for the design of Virtual Reality Exposure Therapy (VRET) systems. Exposure therapy is the established method for treatment of anxiety disorders and is typically delivered in-vivo, i.e. exposure to phobic stimulus in real environments. Virtual reality (VR), instead, offers the potential to conduct exposure therapy at the clinic. This approach has several benefits in terms of efficiency, customization and control, amount of exposure, and as an transition phase to real situations. However, currently many systems are limited in scope and are designed for research purposes without informing the design from therapist’s practices.

My research aims to contribute towards the understanding of current practices in exposure therapy and investigates challenges for the design of these systems for the two main user groups, patients and therapists. Three different focus areas have been prevalent. First, we have studied therapist in real sessions to inform the design and development of VRET-systems. Second, we have evaluated two different VRET implementations supporting therapists to interact with patients. Third, on the patient’s side, we have studied presence on healthy participants focusing on the influence of virtual bodies and patient movement in VR.

This thesis summarises and discusses these studies. Overall, the studies emphasize the complexity of exposure therapy and the need for individualized patient conditions. This poses multiple challenges for the design of VRET-systems such as, first, the systems must offer flexibility to the therapists to orchestrate individualized therapy. Second, the systems must enable rich therapists-patient interaction. Third, the complexity of individualization of scenarios and sessions must be addressed in the design of the therapist’s interface. Fourth, for patients, body avatars influences presence differently depending on the scenario and locomotion is challenging as offices are typically small.
Sammanfattning

Denna fil ger ett avhandlingsskelett. Mer information om \LaTeX\-mallen finns i dokumentationen till paketet.
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Chapter 1

Introduction

Mental disorders lead to tremendous costs that the health-care systems have to bear [48, 16]. Among mental disorders, anxiety disorders are the most common with a 12-month prevalence of 18.1% [52] and a lifetime-prevalence of 28.8% [18]. Evidently these disorders affect a large population. Exposure therapy is a highly effective method in cognitive behavior therapy (CBT) that features response-rates of 80 - 90% [4, 18].

During the course of exposure therapy, patients get exposed to phobic stimuli that are orchestrated by a therapist. Traditionally, this exposure is conducted \textit{in-vivo}, which means being exposed to situations that trigger the patients phobia in the real environment, or \textit{in-situ} using the patient’s imagination. During exposure, a therapist is leading the therapy though conversations challenging the patients phobic responses and thought patterns.

Virtual Reality (VR) instead offers the opportunity to conduct exposure therapy \textit{in-virtuo} using VR to deliver phobic stimuli, so called Virtual Reality Exposure Therapy (VRET). One early example of VRET is Rothbaums [35] work in the early 1990ies that focused on the application of VR in the context of fear of height. In recent years, clinical studies of using VRET compared to \textit{in-vivo} exposure have also demonstrated that the VRET is sufficiently efficient. For instance in treatment of fear of height (acrophobia) [8], fear of flying [28, 29], and social phobia [17].

VRET offers several advantages compared to traditional \textit{in-vivo} exposure. First, it saves time and thereby leads to more efficient exposure therapy [24]. In current practice, therapist have to spend time planning and traveling to remote locations for exposure. Using VRET, exposure can instead be conducted at the clinic. This could also be considered as a safe environment [33]. For example, exposure treatment of acrophobia may require traveling to a high building. Secondly, stimuli and scenarios can potentially be quickly customized and controlled by the therapist and real-time performance feedback can be provided [33]. Thirdly, there is also evidence that patients are more willing to approach VR-based exposure as it appears as a natural in-step towards real situations [14]. Fourthly, Rizzo and Kim argue for the ecological
validity, that is defined as the degree of similarity to the tasks and actions in the real world [33].

However, there are many challenges for the development and design of VRET-systems. First, the systems are currently developed for research purposes and used accordingly. This implies that most patients suffering an anxiety disorder have no access to this type of therapy in regular therapist practice. To improve the systems that in the future can be used in therapists practice, the systems have to support or improve the established processes of the therapists.

As regards current efforts on designing VRET-systems some concerns have been raised around stakeholder involvement. For instance, Rizzo and Kim [33] have highlighted that the design and development of these systems need to be done more thoughtfully, interdisciplinary and user-centered. Furthermore, Mohr et al. have also concluded in a recent article that VRET-systems tend to be developed top-down, implying insufficient involvement of all users [27]. They explicitly challenge the community to work interdisciplinary in hope to foster a change in the traditional thinking, benefiting the development of VRET-systems. The two main users groups that need to be involved are patients and therapists.

On the patient’s side, research indicates that presence, which is defined as the "sense of being there" [51, 45], has influences on the self-reported anxiety [22] and therapy outcome [6, 3]. To ensure effective therapy, designs of VRET-systems have to consider influencing factors of presence as for example the thoughtful use of locomotion and representation of the user’s virtual body [37].

In this thesis, I aim to contribute to increased understanding of the field of VRET and the design of VRET-systems. The work presented here is rooted in an interdisciplinary HCI-perspective accounting for both patients and therapists. The goal is to extrapolate design challenges in order to better support interactions between patients and therapist that are necessary in the course of a therapy.

1.1 Research Objective

My research started with an interest in how VR can be used in professional environments. Stemming from my background in Medical Informatics, psychotherapy became very interesting. In the beginning I focused on creating 3D virtual environments for therapy but over time the focus shifted towards the HCI issues and interactivity, which is the focus in this thesis.

The aim of my research is to understand the process of a therapy and use that understanding to explore how we can support therapists and patients through the design of VRET-systems. In this thesis I look specifically at the underlying challenges facing the design of interactive VRET-systems. This lead me to the following research question (RQ):

- **What are the challenges for designing a VRET-system to support therapist’s and patient’s interactions?**

This thesis aims to explore the field of therapy and VRET-systems from an
1.2. STRUCTURE OF THE THESIS

HCI-perspective. This implies two views, as we have two main user-groups: therapists and patients. During my research, I strove to involve both groups. From the therapist’s perspective I wanted to contribute to the understanding of their tasks during, and approaches towards, therapy. The patient’s side was researched using in-lab studies that focused on new concepts that can be used to enrich exposure therapy sessions. In particular, I have been interested in the participant’s experience and felt presence while they are immersed in VR and are using the tested concepts. During my research, I found challenges that VRET-systems has to address in order to support therapists and patients in therapy of anxieties disorders.

1.2 Structure of the thesis

The thesis is presented as compilation thesis, which implies that it is grounded on previously published research papers. The aim of the thesis is thus to give a high level overview of my research and a meta level discussion on the work conducted. Chapter 1 aims to frame and motivate my research. Also, the research question is defined and described, followed by the papers included and not included in this thesis. Chapter 2 aims to provide the theoretical background of my work and an overview of the field. The chapter contains two parts. I begin with an overview of related concepts from VR and continue to describe the use of VR in exposure therapy. In chapter 3, I give an overview of the methods I applied during my research, the context of the research, and a commentary of ethical considerations. Chapter 4 contains a summary of the conducted studies that includes retrospect reflections that provides motivations for the path of my research. In chapter 5, I discuss the results of the studies on an abstract level in relation to the RQ. Chapter 6 concludes the my work and discussions and addresses the RQ by outlining interesting challenges for VRET-systems. The thesis ends with the chapter 6.1, which contains potential future work and directions.

1.3 Papers included in the thesis


My contributions: I took part in the ideation, design and implementation of the system. Philip Schäfer conducted the evaluation and data analysis with support from Julia Diemer. Also, he led the writing process with support from Gerrit Meixner.

**Paper II:** M. Koller, P. Schäfer, M. Sich, J. Diemer, M. Müller, G. Meinxer. Next Generation Virtual Reality Exposure Therapy Systems - A Study ex-
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Exploring Design Implications. *2018 International Conference on Intelligent Systems (IS)*. IEEE.

My contributions: I planned and conducted the qualitative study along with Philip Schäfer and Magdalena Sich. Magdalena Sich along with Julia Diemer and Mathias Müller designed the questionnaire and conducted the quantitative analysis. Magdalena Sich analyzed the data statistically. I was responsible for the main outcome and writing with support from Gerrit Meixner and all other authors.


My contributions: The system was implemented by Daniel Lochner with the support of Philip Schäfer. I contributed to the study plan and participated in the conduction of the study along with Daniel Lochner and Philip Schäfer. I was then responsible for the data analysis and main outcome. Philip Schäfer and Gerrit Meixner supported the writing process.

1.4 Papers not included in the thesis

During my research I have also been involved in the following work with little relevance to my thesis. The two first listed publications were presented as posters at a workshop, the second listed poster lead to Paper III which is included in this thesis.

M. Lüönd, P. Schäfer, M. Koller, G. Meixner. New conceptual approaches to meet the spatial and user safety requirements of outpatients with anxiety disorders for virtual reality exposure therapy. Poster presentation at 2018 Virtual Environments: Current Topics in Psychological Research (VECTOR) Workshop, Tübingen, Germany.


Chapter 2

Theoretical Background

In this chapter, I will introduce concepts that are the basis for my work. First, I will give a short introduction into Virtual Reality and describe concepts that are most relevant for my work. Second, I will describe the use in clinical settings. The chapter concludes with an overview of VRET.

2.1 Virtual Reality

Ivan Sutherland presented the first version of a head mounted display (HMD) in 1968 [47]. In his work, he describes the idea of creating a three dimensional picture on the retina of a user. The idea and technology evolved over time and became technically more sophisticated.

The user’s experience in VR is characterized mainly by two dimensions: immersion and presence. These terms are sometimes used as synonym, while they describe different phenomena. Slater and Wilbur define immersion as the technological description of an immersive computer system [45]. According to the authors, immersion depends on hardware, software and peripheral systems, i.e. systems that are not directly related to VR such as tracking systems. The critical factor for displays is the vividness which is formed for instance by the resolution and inclusiveness (the degree to which the physical world is shut out). More general, Slater et al. define it with “richness, information content, resolution, and quality of the displays”. Furthermore, Slater et al. note, that body mapping is central for immersion [42]. This implies that the movement should be synchronous in the real (i.e. physical) and virtual environment.

Presence is characterized as the sense of being in a virtual environment instead of the physical environment where user’s body is attendant [45, 51]. Slater and Wilbur acknowledge presence as a central part of a user’s experience in VR [45]. Presence is formed by factors that contribute to the user’s experience. Sanchez-Vives and Slater define these factors as follows: [37]:

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CHAPTER 2. THEORETICAL BACKGROUND

• Display: Displays influence the sense of presence with different parameters. A central measure is the latency between head-movement and update of the display. Studies show that the frame-rate is correlated with the presence reported by subjects [2]. Furthermore, the field-of-view, which is a relative measure for the observable world restricted by the HMD, is an influencing factor for presence.

• Visual realism: Here, research shows contrary indications in regards to the need of visual realism in VR. In general, VR strives to maximize the visual realism. However, Rizzo and Koenig conclude in their review that in clinical use, visual realism is of less importance [34].

• Sound: The auditory dimension is suspected to influence presence and perceived illusion of self-motion [32]. Furthermore, Sanchez-Vives and Slater state “anecdotal” reports on a higher presence when using sound [37]. The use of sound in clinical VR ranges from performance-feedback to the delivery of a more realistic stimulus [34].

• Haptics: Haptics influences presence, although the sense of haptics is currently not easy to generate with external devices. To overcome this, the use of low-fi versions of physical objects may be used. The authors explain this with the example of a table-top which can easily be simulated with a plasterboard [37].

• Virtual body representation: When users are immersed in a virtual environment they have no visual representation of their body by default. The representation of a virtual body affects the presence. The representation of the user’s virtual body is employed in various ways in clinical VR, for example in the context of eating disorders [38].

• Body engagement: The authors refer here to the fact that in immersive environments that provide a high presence users attempt to walk physically, which is limited with cable-based systems. Other methods of locomotion should be used in order to allow the movement in VR and provide a high presence, for instance Walking In Place (WiP) [44]. Usoh et al. conclude in their study that natural walking is superior to WiP [49]. Locomotion is also important in clinical VR and anxiety therapy. Some exercises in exposure therapy require approaching (e.g. walking towards) an object, which implies that patients must have this opportunity in VR, as well.

Presence is a subjective measure [45] and, therefore, it has to be assessed by the subjects experiencing the VR. Presence can be assessed in different ways, which indicate an overall level of presence [37]. The methods can be categorized to in-experiment assessment and post-experiment assessment. In addition to the subjective dimension, more objective dimensions or observable dimensions can be added and contribute to the presence:
2.1. VIRTUAL REALITY

- **Behavioral dimension:** In this dimension, the user’s behavior in the virtual environment and physical world are assessed, i.e. it is an in-experiment dimension. One example is when the participants try to interact with the virtual world even when it is not possible (e.g. start walking).

- **Subjective dimension:** This dimension evaluates the perceived and felt presence of the subjects. During the experiment, the participants can be asked to rate their current level of presence. After the experiment, there are questionnaires that are able to create a presence score.

- **Physiological dimension:** This dimension contains the uncontrollable body reactions, for example heart-rate and galvanic skin conductance. Particularly in the case of emotional activation or Breaks in Presence (BiP) [41], physiological responses may occur.

Questionnaires are discussed controversially within research. On the one hand, they are often applied in experiments. On the other hand, there is critique that their results are unstable [11]. The main argument is that these questionnaires are filled by the participants after they concluded their experiment, i.e. after experiencing the VR. This raises doubts if participants may not recall everything correctly. A study where participants experienced a scenario within an office in real-life and VR illustrates the critique [50]. The authors of this study hypothesize that the presence score of the group experiencing the scenario in real-life should be higher compared to the group in VR. However, the questionnaires failed to provide a significant difference between the groups.

Slater criticizes the concept of presence as abstract [40]. Furthermore, Slater states that participants cannot relate to this concept in their real-life. Therefore, he argues that participants cannot provide an adequate assessment. Other measures such as anxiety levels are considered by Slater as valid, since participants can clearly relate to it and compare (e.g. stimulus A provoked a higher level of anxiety than stimulus B). Slater concludes that presence is still valid and future research will be able to relate it to a detectable mental state.

The movement of participants in virtual environments – called locomotion – is a key feature of VR [39] and it influences the patient’s presence [44, 49]. In the therapy facilities, we encountered relatively small offices that offer limited space for free movement. In addition, systems for clinical use must also be designed for use by impaired persons. In research, there are different implementations for locomotion that have advantages and disadvantages [39]. The following listing summarizes the most common implementations along with their advantages and disadvantages.

- **Abstract methods:** Systems may use game-pads or joysticks for navigation in the virtual space.
  - **Advantages:** The concept of controller is common, especially in the younger generation. Furthermore, this method needs little space and can be used while standing still or sitting.
Disadvantages: Locomotion by controllers is known to cause motion sickness [12]. Besides, both hands are occupied while immersion which influences the interaction with the VR.

- Walking in Place: This method needs the user to walk or jump at the same place which is captured by the HMD with internal sensors and translated to steps in VR.
  
  **Advantages:** This method needs little space to explore the whole VR. Today, in most HMDs the required sensors are integrated and, therefore, no external equipment is needed.

  **Disadvantages:** The method is less intuitive compared to natural walking and is physically demanding at the same time. It can cause problems with latency and smoothness of the movement.

- Treadmills: In these platforms, users are mounted and must make sliding-movements with the feet that are then translated in steps in the VR (c.f. figure 2.1, a person using the the Cyberith Virtualizer\(^1\)).
  
  **Advantages:** The systems allow the movement in any direction of the VR by a limited space needed. Furthermore, because of the mount that the users are attached to these platforms offer more security than for example WiP.

  **Disadvantages:** To place the system in domestic environments or offices, there possibly is the need for a re-arrangement. These treadmills currently are not able to simulate obstacles or uneven terrain.

- Natural walking: Users are tracked and able to walk within a defined space naturally and freely.
  
  **Advantages:** This method is the most natural way of locomotion and potentially presence enhancing. Almost no training is needed and obstacle collisions are less likely. Natural walking support the process of cognitive map building which improves the navigational performances. [36]

  **Disadvantages:** This method needs as much space as the user can potentially walk. This implies that the scenarios have to be adapted to available space. The method might not be usable by impaired users, what is a criterion for clinical VR [33].

In some cases, the circumstances require to combine locomotion methods. One example is the limited space in natural walking. In this case, the combination of natural walking and abstract methods, as for example a controller-based teleportation, can solve this issue.

\(^1\)https://www.cyberith.com/
2.2 Clinical Virtual Reality

Virtual Reality has various fields of application, among them the use in medical use-cases. There, we find applications in training of professionals [1, 25] and in therapy and rehabilitation (e.g., after surgical interventions [19] or after a stroke event [54]), called clinical VR.

On a general level, Rizzo and Koenig characterize role of VR in clinical as follows [34]:

- **Expose**: Deliver a specific stimulus that the patient should be exposed to.
- **Distract**: Distract the user from pain or other feelings of discomfort during treatments.
- **Motivate**: Integration motivating elements that help the patients to repeat monotonous exercises.
- **Engage**: Show the benefit to participate in the clinical intervention.
- **Measure**: Measure of performance on behavioral or cognitive levels.
As the term already suggests, VRET can be characterized as system that exposes patients to a stimulus.

**Virtual Reality Exposure Therapy**

Anxiety disorders are among the most common mental disorders in Europe and the US. Cognitive behavior therapy (CBT) offers the therapy method exposure therapy, which is considered to be effective. In exposure therapy, a therapist guides a patient while he/she is exposed to a phobic stimulus which can be an object (e.g., spider) or a situation (e.g., public speaking). The traditional therapy is conducted *in-vivo*, which implies that the patient is exposed to the phobic stimulus in a real environment, or *in-situ* meaning in the patient’s imagination. By introducing VR to exposure therapy, the phobic stimulus is delivered in the virtual world.

The therapy method has been researched since the 1990s in a first study on the use of VR in acrophobia [35]. The research continued and multiple studies show the efficiency of the therapy in VR [8, 28, 29, 31]. The systems advanced over time and are now able to cover greater variability of phobias involving more complex interactions, e.g. social interactions. However, the systems are mostly designed for the purpose of research and big clinical settings. Therefore, the patients that suffer from anxiety do not benefit from the systems in general, as these systems are not widespread in small practices where most patients receive this treatment. With the advent of advanced VR technology, the prices for VR hardware dropped and make now the cheaper development of these systems possible. Studies show that the state-of-the-art consumer hard- and software delivers similar results compared professional systems using older hardware [21].

Research mainly aims for the development of systems which are used for therapy guided by a therapist. However, the therapists are not in the focus of most of the published work. The work puts the patients to focus observing various parameters, such as felt presence during the immersion in VR. Presence is an important measure when it comes to VRET. Research indicates that there is a correlation between the felt presence and anxiety [22] as well as presence and therapy outcome [6, 3].

With the wide spread of advance technology in consumer market, research is investigating the opportunity of patient-led therapy. These systems offer applications that users can deploy on their own hardware and then be exposed to a phobic stimulus. While there are applications that are fully patient-led after a first therapist-led session [20], other systems provide the home-based exposure under the in-direct supervision of the therapist [15]. Both exemplified systems have in common that they provide *psychoeducation* for the patients using an agent. Lindner et al. hypothesize this as important therapy component [21]. Psycho education aims to provide information regarding the illness, access and learning strategies for the patients [5]. Psycho education cannot be considered as a treatment but as a tool to help patients in dealing with the disorder.

The use of modern VRET-systems brings advantages for the therapists. Using the systems, they can conduct therapies with phobias that are hard to generate
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In-vivo, e.g. fear of flying or public speaking anxiety (PSA) [24]. The challenge in PSA is to have an audience that is controllable by the therapist and is acting as intended by therapists. With the use of VR, virtual audiences can be generated that can be orchestrated by a therapist. Furthermore, therapists are able to control all parameters of the virtual environment and deliver controlled stimuli. Another advantage of VRET-systems is that the scene can be reproduced in each therapy session, which is challenging when conducting a therapy in-vivo. Furthermore, research indicates that patients are more willing to engage with a therapy that is delivered in VR [13]. As Botella and colleagues state, this topic is researched in few studies and in their review they can only conclude on a trend towards a high acceptance among the patients [3].

Rizzo and Kim published a Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis of VR in rehabilitation and therapy [33]. The analysis was made in 2005, which is before the most recent technological developments that have lead to the current generation of VR-systems. This fact influences the transfer of the described results to the current state-of-the-art. Especially, those weaknesses which are related to the technology might have become obsolete. Here, I will describe weaknesses and threats from their analysis and discuss them based on the current state-of-the-art and in relation to my RQ.

Weaknesses: A weakness is defined as a risk, defect or short coming that affects the progress towards the goal.

- Interaction Methods:

The authors point out that the use of natural interaction methods is of high priority in therapy. They emphasize that the use of new interaction methods need a high amount of (usability) testing before they can be brought to clinical tests.

Currently, the advances in technology offer more natural interaction methods that are driven by research and industry. The shift of VR towards the consumer market provides the opportunity that more sophisticated solutions are available. Also, with the advance in technology evaluations (e.g. new interaction modalities) can be conducted more easily.

As stated in their article, impaired users are still in need of specific solutions that partly need to be developed. This weakness is still a challenge to be addressed in future development.

- Immature Engineering Process for VR-Based Rehabilitation Systems:

The authors describe shortcomings in the development of VR applications. One example they mention are usability problems caused by the lack of on-site hardware that developers can use to test. State-of-the-art hard- and software allows the developers to test their development right away. A short-coming
that is related to the engineering process is lack of focus on clinicians which are one of the main user-groups of these systems.

- **Displays and Wires:**
  Most of the points, the authors critique in this section can be considered as obsolete. The substantial advance in display technologies has lead to systems that today offer a better resolution and field-of-view. Furthermore, state-of-the-art systems provide marker-less tracking that allows full-body tracking within a large space, and wireless transmission connection between the HMD and computer. Still, external systems (e.g. additional external sensors) are needed and employed in current systems, some of them require a cable-based connection.

  For presence, the described short-comings are all influencing factors. As described above, all factors characterizing the display are influencing presence. Furthermore, the use of cables is affecting presence negatively.

- **Front-End flexibility:**
  The authors state, that "user-centered design" of clinical VR systems is a central matter that needs to be addressed during the development.

  This weakness is still present, as the innovation is often made top-down [27]. As argued by Mohr et al., the integration of the clinicians as users is crucial to to the success of these systems. Also, patients as users need to be integrated in the process. In VRET presence is of central importance. Therefore, the design should aim to provide a highly immersive experience.

**Threats:** Any unfavorable situation that has negative impact on the overall aims.

- **Cost-benefit proofs are missing:**
  The authors argue for more cost-benefit-proofs for systems employing VR. They argue that the health care system is not willing to pay for these solutions if there is no economic gain. This not only includes the direct costs, but also costs that may be saved by sending the patients earlier to work (i.e. indirect costs).

  The advance in VR and its enabling technologies led to a significant drop in prices for such systems. Furthermore, the skill to develop VR is spread wider. However, costs are a major concern and state-of-the-art systems still have to proof their benefit.

- **Perception that technology will replace therapists:**
  The authors analyze that there is the perception that VR will eliminate the need of therapists. They exemplify this with the advance of development of virtual humans that may replace therapists. Furthermore, the broader access to VR-applications for treatment might motivate patients to try self-treatments.
The development of applications using VR for therapy has advanced and so did the research on virtual humans. For instance, they are integrated in applications for treatment to provide educational content to the user. As many state-of-the-art smartphones are capable to display VR content (e.g. using a cardboard solution), such devices are widespread and with them the access to VR. A recent study showed that the use of freely available applications in the context of exposure therapy is possible and provides a similar therapy outcome compared to traditional therapy [20].

This brief review of the past challenges and their relation to the current state-of-the-art shows that there is still room for improvement. Despite the advancements in clinical VR, the systems are not widespread in the day-to-day practice. These advancements continuously pose new challenges for the design of VR systems.
Chapter 3

Methods

In this section, I will first give a theoretical overview of design and development in mental health settings. In the second part will focus on an overview of my research and how the theory influenced my research focus and process. Then, I will present the context of my research, which is partly conducted in an interdisciplinary research project. The chapter ends with a commentary of the ethical considerations undertaken in my work.

3.1 Conducting Research in Mental Health

The field of my research is anchored in clinical VR, in particular I conducted research in the field of mental health. This highly sensitive field requires special considerations in the technology design process.

Coyle et al. conclude that in technology for mental health care are two main end-user groups present: the mental health care professionals (e.g. therapists) and patients [5]. This implies for human-centered approaches that researchers ideally need to investigate therapists and patients. However, Coyle et al. conclude that very few HCI-professionals satisfy the requirements to get access to these sensitive environments granted [5]. In order to be able to involve the user-groups from early on, they propose an adaptation of the human-centered development process which is depicted in figure 3.1.

The process consists of two phases. The first stage aims to explore technology and develop first prototypes of systems that can be evaluated to provide evidence for benefits in the desired use-case. The evaluations in this stage are conducted with healthy participants and have a non-clinical character. The second stage focuses on clinical evaluations to provide implications for the use in therapy. In this design process, the evaluations of the first stage should be lead by HCI-researchers while those on the second stage should be lead by clinical-researchers.

Doherty et al. specify the process and provide recommendations for the design process of technology for mental health [7]. First, the authors recommend to define
goals or outcome that the design aims for. This will help to provide a design rationale and success measures for a project. To define the outcomes in the setting of mental health, the authors provide two points to consider:

- Increase the capacity of the service and the availability for people needing it.
- Improve the therapy outcomes by improving the treatments in terms of engagement and effectiveness.

Second, the authors recommend to design in collaboration with the mental health care professionals. Contact with professionals is considered easier compared to contact to patients due to restrictions in therapy sessions like confidentiality. The authors conclude that the building of an interdisciplinary team requires all team members to gain knowledge of the other fields and teach the team members about their field.

The integration of mental health care professionals can be in the context of an adapted human-centered design process which is the third recommendation by the authors. Supporting the two-phased design process depicted in figure 3.1, the authors propose evaluations in three stages. First evaluations can be conducted in-lab with healthy participants. The following evaluation can then be characterized as
3.2. OVERVIEW OF THE RESEARCH

The work presented in this thesis is within the first phase of the design process for mental health technology. The evaluated systems from Paper I and III are in the phase of exploration and first evaluation. Both did not proof their benefit for therapy, yet. However, they indicated to be useful in exposure therapy (e.g. increasing flexibility) and should be evaluated in another evaluation with therapists.

Figure 3.2 depicts the process of my research along with potential future work. The research can be categorized in two views that are argued for by Coyle et al. [5] - the perspective of patients and therapists. My research started with a first exploration of consumer VR hardware in the field of VRET. With our first evaluation, we focused on the patient’s view. In particular, we assessed the impact on a subject’s presence using our system. This first experience posted further research questions. One among them addressed the therapists as future users of the system and the interaction with the system in the context of a therapy.

This lead to Paper II, that summarizes an analysis we conducted to understand therapy and therapists. With this study, we intended to address the previously concluded need for therapist involvement in the design of technology in clinical VR [27]. This resulted in implications that a VRET-system should address.

One of these implications is the need of flexibility within therapy in general and especially within therapeutic scenarios. Based on this hypothesis, we designed a solution that provides the therapists with more flexibility in one specific type of therapy (public speaking anxiety). We evaluated this system, first from the view of an immersed user, which are the patients when the systems comes to real use.

The results indicate possible future work that intends to address both user groups again. As a first step, we plan to evaluate the system that is presented in Paper III together with therapists. Again, we will not use patients because we think the system is still in the first phase of the design process for mental health. We aim to gather feedback on both sides of the system, the therapist’s and the
patient’s perspective. Therefore, we plan to ask therapists to role-play typical patient behavior. We expect therapists to provide valuable feedback when they experience the patient’s side of the system and at the same time we can evaluate the interaction between therapist and our system.

Additionally to the two views within my research, we can identify two strands: exploring VRET and understanding therapy. Among the first things I realized from literature is the importance of patient’s presence during the therapy. Assessing presence in our experiments, we employed three dimensions that are indicated by Sanchez-Vives et al. [37] - subjective, behavioral and physiological dimension. First, the subjective dimension was assessed using in-experiment and after-experiment methods. The assessment of presence during an experiment is done by asking a question like “On a scale from 0 to 100, how present do you feel in this situation?” while the participant is immersed. This subjective in-experiment measure can be supported by the behavioral dimension. For this, in our experiments we used the observation of the immersed participants. We noted for example that they started walking, while they were not supposed to, or interacted with the virtual audience.
3.3. CONTEXT OF MY RESEARCH

as they would regularly (e.g. pointing to an avatar while giving the permission to speak). A further dimension during the experiment are physiological measures that indicate a emotional activation, e.g. heart-rate or galvanic skin conductance. In one experiment (Paper I), we used the heart-rate as measure. In Paper III, we did not come back to this measure as we did not expect to gather significant data. When the experiment is concluded, questionnaires or interviews can provide data on the participant’s presence. Traditionally, specialized questionnaires are used, for example the Slater-Usoh-Steed (SUS) [50]. In our most recent study (Paper III), we interviewed the participants after the experiment. In the gathered data, we were looking for evidence that indicates the level of presence.

Despite the limited access to patients and therapists as described by [5, 7], we were able to get direct contact with therapists and patients during a therapy within the context of our research project. To gather an even better understanding of the therapy and follow up our interdisciplinary discussions (see above), we got access to therapy sessions that we were allowed to observe. Furthermore, interviews with therapists were conducted. However, due to ethical considerations and to not interfere with the therapy we did not directly talk or interact with the patients before, during or after the therapies.

3.3 Context of my research

Starting from Paper II, my research was conducted with a research project funded by the German Federal Ministry of Education and Research (Grant-No.: 13GW0169A) named EVElyn. The research project consists of one research institute, where I am affiliated, an industrial partner and a psychiatric clinic. Hence, the project combines competences from the fields of computer science and psychology.

The project aims to address the increasing demand of therapeutic interventions in anxiety disorders in out-patient settings. For this, the project incorporates three views on VRET-systems: the technological perspective, the psychological perspective and the user perspective. The project aims to investigate the possibly significant increase of efficiency of the therapy process.

The project helped my research with the direct contact to psychologists. They provided insightful feedback on early ideas and contributed to the understanding of therapy. The work presented in Paper II was conducted in the context of this project and with the support of all three institutions.

3.4 Ethical Considerations

The research using VR has to consider ethics in particular as participants are fully immersed and we create a feeling of embodiment in some cases. Madary and Metzinger are proposing a code of ethical conduct for research that uses VR and recommendations for its application [23]. As essential principle, the authors consider the "non-maleficence", i.e. do not harm any participants. This basic principle is
also anchored in the Declaration of Helsinki, which demands the physicians to act in the patient’s interest when giving medical care also for research purposes [53].

Among others, Madary and Metzinger focus in their recommendations on VR in clinical use-cases. Research within this field should be conducted in close cooperation with clinicians. This demand is in-line with the design process in mental health settings [5, 7]. Furthermore, the progress and research should not create ‘false hopes’ in patients. Their ethical code of conduct demands researchers to be honest with the scientific progress and the experimental nature of their research. One reason to do so is, that these groups can be considered as specifically vulnerable and therefore need special protection [53].

Coyle et al. propose four considerations that aim to help to meet ethical requirements [5]:

- Technologies should be based on accepted theoretical models of the specific domain.
- Technologies should be designed with the involvement of health care professionals.
- Technologies should be able to integrate in the current methods and work flow.
- Technologies should be used with therapists guiding.

In my research I strove to meet these four considerations by Coyle et al. in all phases and studies. The first point is represented in our aim to understand the setting of the therapy and the therapy itself. This leads to the second and third point that demand a involvement of the therapists and the demand of designing systems that can be integrated in the current process. Both are present in my work as I am aiming to understand the therapists and their tasks. Their last point addresses the nature of a system. There are self-help applications freely available that can be downloaded. The authors argue against the development these applications. In the case of my research, we are developing a system that is used in the presence of a therapist, only.

The ethically most problematic study presented in this thesis is Paper II. For the work presented we had direct contact to therapists and patients in the course of therapy sessions. During the observation of this very intimate conversation, we had a passive observational role. The therapists were informed by us about the aims and focus. They selected patients they thought are fitting and informed them about our research. Together, they agreed and signed an informed consent form. To ensure the anonymity of the patients, we stored all forms that indicated to patients separately for all data. To not interfere with the therapy, we did not talk to the patients before, during, or after the therapy. Furthermore, to protect the patient’s identity and rights we published our results in a way that does not disclose from whom and where we received the data.
3.4. ETHICAL CONSIDERATIONS

The studies presented in Paper I and III were performed as in-lab studies and ethically less problematic. We considered the general ethical code of conduct using VR [23] in the design and execution of the experiments.
Chapter 4

Overview of the studies

In this section, I will give a short overview of my research and how it was influenced and motivated. Furthermore, I will provide a brief overview of the research project in which some of the research was conducted. The third part of this chapter are short summaries of the backgrounds, methods and results of each study that was presented as paper.

4.1 Summary of the papers

Paper I: Development and evaluation of a virtual reality-system with integrated tracking of extremities under the aspect of Acrophobia

Full paper presented at 2015 SAI Intelligent Systems Conference (IntelliSys), London, UK.

Authors: Philip Schäfer, Marius Koller, Julia Diemer and Gerrit Meixner

Background and aims
Presence of an immersed patient is recognized by research as one of the key factors that influence the therapy outcome. Many factors contribute to the sense of presence during the experience of VR. We created a system that allows the tracking of extremities using a Microsoft Kinect sensor. The main enhancement was that the patient is now able to lift for example the leg and the same movement is translated to the VR. For evaluation we used a scenario that was designed for acrophobia (fear of height). Figure 4.2 depicts a participant using the system (cf. figure 4.1a) and the participant’s view in the scenario containing an avatar and enabled tracking of extremities (cf. figure 4.1b).

Methods
For evaluation we invited 42 people with no diagnosed phobia. They were divided in two groups by assigning 21 participants to each group. Group one experienced the patient’s avatar with the tracking of extremities. Group two, which was the control group, experienced the basic functions without an avatar. We measured the presence in different ways. First, in specified situations we asked the subjective level of presence (“How present do you feel in this situation now?”). Second, we recorded the heart-rate and analyzed it to receive a feedback from the physiological values. Third, we observed the participants during the experiment and noted their behavior on paper. The last dimension, we handed out the presence questionnaire from IGroup, called IPQ.

During the experiment we had different scenes that the participants experienced. First, they were set into a scene for acclimatization. This scene had no phobic stimulus as the patient was standing on the street and experiencing the scene. For the second scene, the participant was teleported to a balcony which was secured. As last scene, the participants were on an un-secured protrusion. The last scene had the highest phobic stimulus.

Results
On the subjective dimension, the group using the tracking system and the avatar
scored a higher presence score compared to the group without the tracking system (and hence, without avatar). Using the t-Test we were able to confirm a trend in the subjective dimension. The post immersive measurement using the IPQ only showed a trend in spatial presence, all other items were not different between the group significantly. On the behavioral dimension we observed that 12 (10 participants from the tracking group) out of 42 participants tried to interact with the virtual word. The Fisher’s exact test indicates a significant difference between the groups. The measurements of the heart-rate were assessed based on the scenes the participants experienced. To compare the values, we subtracted the baseline heart-rate by all other values. Using the t-Test we did not get any significant differences in the group.

This study made us aware of the challenges that patient’s presence posts to the design of VRET-systems. Furthermore, we concluded that the technology available has the potential to contribute benefits to the therapy of anxiety disorders. However, we noticed that designers of these systems need to be well-informed about the consequences of their design decisions. This lead us to the next study which aims to contribute to the understanding of exposure therapy.

Paper II: Next Generation Virtual Reality Exposure Therapy Systems - A Study exploring Design Implications

Full paper presented at 2018 International Conference on Intelligent Systems (IS), Funchal, Portugal.

Authors: Marius Koller, Philip Schäfer, Magdalena Sich, Julia Diemer, Mathias Müller and Gerrit Meixner

Background and aims
This paper aims to understand the current practice of exposure therapy and to draws design implications for these systems. The systems have to support the therapists in their daily practice and hence should be well integrated into the therapy process.

Methods
We used different methods to gather our data. First, we sent out an online-questionnaire to reach as many therapists as possible. We were asking general questions regarding their experience in therapy and characteristics of such systems they want to have. Furthermore, we observed therapists during therapies and interviewed them afterwards. The data we gathered were aggregated and combined. Using the combination, we concluded design implications for VRET-systems. Due to ethical restrictions we were not allowed to record any conversations or take pictures.

Results
As main result of this work we concluded that the process of therapy is complex. Consequently, VRET-systems that aim to support the therapy need to cover this complexity. This lead us to design implications for VRET-systems. We saw the need for flexibility in the VRET-systems because the patient’s are individual and so are their needs for therapy. Furthermore, we concluded that therapists are practicing in small offices with little available space for locomotion. From the challenges we found, we wanted to address the therapist’s need of flexibility first because we intended to design our system iteratively by adding new concepts that must be tested in non-clinical environments first. This lead to the design and implementation of the system that is presented in our next study.

**Paper III: Rich Interactions in Virtual Reality Exposure Therapy: A Pilot-Study evaluating a System for Presentation Training**

Full paper submitted to 2019

Authors: Marius Koller, Philip Schäfer, Daniel Lochner, and Gerrit Meixner

**Background and aims**

This paper evaluates a system that addresses Public Speaking Anxiety (PSA). Research indicates that the training of presentations lowers the anxiety level and increases the speaker’s performance. The VR contains a virtual audience that is placed in a classroom and listening to the presenter. The avatars can be controlled from the outside to interact with the speaker verbally and non-verbally.

**Methods**

For evaluation we conducted a study with 24 healthy participants that were divided in two groups. One group received dynamic live-interaction from an orchestrator that is outside the VR. The other group received pre-defined animations for non-verbal interaction and pre-recorded statements and questions as verbal interaction. Both groups presented the same presentation and had the same questions to ask and answer.

Before the experiment started we handed out several questionnaires evaluating demographics and a tendency towards social anxiety. During the experiment, we observed the presenters while presenting. When the participants completed the presentation, we handed out a questionnaire evaluating social- and co-presence. The experiment was concluded with a semi-structured interview that should provide us with insights on the subjective experience from each participant.

**Results**

Our results indicate that the verbal interaction with an orchestrator from outside the VR has a high influence on the presenter’s experience. Participants frequently
4.1. SUMMARY OF THE PAPERS

(a) The orchestrator’s view from outside the VR.

(b) First-person view from the patient.

Figure 4.4: Two views of our system’s virtual environment.
asked follow-up questions on answers that were given by an avatar. In the condition with live-interaction, the orchestrator was able to respond to any question spontaneously. Without the live-interaction, no further answer was given as spontaneous responses cannot be pre-recorded.

The take-over of avatars and live input on their upper-body movement did not impact the participant’s overall experience. The participants did not mention a break in their perception when the orchestrator took over an avatar. This indicates that the transition from synthetic animations to natural live-input can be used in future use-cases.

We conducted the study with healthy participants and without therapists orchestrating the scene as we took over this role. This implies that the results of our study must be validated with therapists as demanded by the development process for mental health technology.
Chapter 5

Discussion

In the discussion, I will begin by summarizing and interpreting my results. This part aims to abstract my findings and bring them into a broader context. Using these interpretations I proceed to focus on the implications with the aim to highlight challenges and future directions. The discussion is concluded by methodical reflections.

5.1 Summary of results

My research consists of two main strands: exploring VRET and understanding exposure therapy. Furthermore, my work is divided by the therapist’s and patient’s view on these strands. In this section, I will first discuss the therapist’s view on both strands followed by the patient’s view.

While conducting the analysis for Paper II, I came to understand how complex and individual exposure and anxieties are. On the side of exposure, we concluded that there is a need for numerous therapeutic scenarios to be able to account even for the diversity within a particular anxiety disorder. One illustrative example concerns arachnophobia (fear of spiders): a therapist explained that there are patients that only fear spiders with hairy legs. Another more complex example concerns patients who have developed a fear of presenting in front of an audience, as this is a social setting the multitude of social interactions potential in such settings are clearly vast and complex and may include emotions, conversations, body language, and other explicit and implicit auditory and visual cues.

As shown in literature [24], VRET may offer the opportunity to conduct planned and controlled exposure therapy using individualized stimuli. This is a clear advantage to in-vivo exposure where factors such as weather (e.g. too bad conditions for being on a roof), social encounters (e.g. meeting a friend during a session), unplanned events (e.g. the train was cancelled), and so on might are undesirable. However, the real world also offers plenty of opportunities to tailor sessions by natural complexity, as it is only limited in this respect to what exists, which is a benefit
for in-vivo exposure. In order for VRET-systems to be a viable option for real therapy, a grand challenge for these systems are to offer flexibility and complexity along with a broad variety of therapeutic scenarios. Otherwise the therapist will lack the tools required to be able handling the diversity of patients. This is in contrast to current research on VRET-systems, which are arguably at early stages of development with limited scenarios and interactions [10].

The possible degree of interactivity of these systems differs within the phobias. For instance, for social anxiety disorders a dialog might be needed, involving direct verbal interaction between the patient and an avatar controlled by the therapist. In arachnophobia, however, no direct verbal interaction is needed to expose the patient to the phobic stimulus. Instead other types of content or interactions needs individualization, e.g. type and number of spiders. This is a challenge for the design of VRET-systems and their scenarios on both, the patient’s and therapist’s, views of the system. The possible individualization of scenarios has to be clear for therapists at every stage of the therapy session in order to support them orchestrating the session and its phobic stimuli. This challenges the design of the therapist’s interface that they must be able to use during the course of a exposure intuitively. From the patient’s view, the scenarios must provide individualization that allows therapists to adapt and orchestrate the phobic stimuli to the patient’s needs and responses. Furthermore, the scenarios must be designed to resemble the world in a way that provokes the patient’s anxiety accounting the possible individualization.

During my research, I realized that clinical VR-systems, and consequently VRET-systems, can be used in different ways. For instance, VRET-systems may be not only useful in exposure therapy but also in other therapeutic contexts, for example in the training of social competences. One use may be in therapeutic role-plays between a therapist and patient as conducted in the training of oral exams. In current practice, the therapists are playing the role of the examiner which implies that the patients are answering to the well-known and probably trusted therapist. Using the concepts we explored in our system for social interaction (Paper III), therapists can embody an avatar what may lead to a different stimulus. In the example of oral exams the therapist may still play the role of an examiner but using our system, the therapist embodies the examiner which may ensure a more realistic experience for the patient.

Furthermore, these systems can be used for training of therapists and nurses in which role-plays are already used [7, 9]. By employing role-play in VR the training of therapists might benefit in experiencing the full view of patients during a therapy session. The two described examples rise the challenge of scalability of these systems to other uses.

During our research on the patient’s side, we mainly investigated the concept of presence and how to create highly present scenarios, which is encouraged by Ling et al. [22]. Research indicates that presence influences the anxiety [22] and therapy outcome [3]. In general, Ling et al. conclude in their meta-analysis that the effect differs on the clinical status and the anxiety [22]. They did not find a correlation between presence and anxiety in social phobias, which may be caused by the current
5.1. SUMMARY OF RESULTS

presence measures that fail to obtain the sense responsible for provoking social anxieties. This circumstance is relevant on our work on rich interactions presented in Paper III where we measured the social- and co-presence [30]. The challenge for future research is to design VRET-systems that address the relevant influencing factors of presence [37] and apply the relevant tools and measures of presence.

The first influencing factor of presence I want to address is locomotion, which here refers to the patient’s movement in VR. In Paper II, we concluded that locomotion is a challenge that has to be addressed when designing VRET-systems. The scenarios developed for anxieties differ in the need of extensive locomotion, e.g. some in-vivo exercises demand the patient to approach a phobic object. In other exercises, locomotion is less important, for instance for patients exposed to a presentation scenario where there is limited space for movement (Paper III). Therefore, it appears important for VRET-system designed to be used for varied exposure to be able to support locomotion. However, this is further complicated by the fact that therapy offices typically are rather small (Paper II), which challenges the design of VRET-systems to account for the patient’s presence while dealing with limited space. This speaks against natural walking and in favor of less space-demanding solutions such as walking in place [43] or treadmills [46]. Both these solutions come with advantages (e.g. less space-demanding) and disadvantages (e.g. physically demanding) and both are not completely replicating the natural walking experience. The locomotion in clinical environments have to account for possibly physically impaired users what challenges the design in a further dimension.

A further influencing factor of presence is the virtual representation of the user’s body. In Paper I we found that a virtual body representation for the patient increased the felt presence within a height scenario. However, most participants in Paper III did not notice or miss the representation of their bodies when presenting in front of an audience. An explanation for this phenomenon might be the nature of the scenarios. While Paper I is in the context of height where the body perception and awareness plays a role, in Paper III the verbal interaction is in the foreground. Interestingly, there is evidence that the body is used as a motor-visual feedback on metric measurements and distance [26]. This leads to my interpretation that a phobia which involves the perception of surroundings with involvement of distances or metric measures needs the body tracking in order to provide a highly present experience. On the other hand, for phobia that involves complex (social) interaction, other dimension of presence may be needed. For instance, avatars and their verbal and non-verbal behavior contribute to a high sense of social- and co-presence. This implies that VRET-systems have to be sensitive to the specifics of presence needed for different scenarios and and relevant influencing factors.

The last challenge I want to address is the design and development process of technology for mental health. During my research, I learned the basics of the field and understood exposure therapy to be able to design systems supporting therapists and patients. I benefited from our interdisciplinary research project that enriched the literature research by adding and explaining backgrounds. However, I consider our partners as clinical researchers which, consequently, leads again to the top-
down development criticized by Mohr et al. [27]. However, in the design process for mental health, the involvement of non-clinical mental health professionals is a central aspect [5, 7], what we accounted for in our analysis presented in Paper II. Still, I gathered feedback on early ideas and concepts from our interdisciplinary partners which informed the design process due to access restrictions to non-clinical therapists. Their feedback was valuable for the progress of our designs. However, in future states the concepts must be tested with therapists without clinical focus. In conclusion of this aspect, more research on the therapist’s side of the systems is needed.

5.2 Implications

On an overarching level, drawing from the need for individualization within each anxiety disorder and for different anxiety disorders, we need to turn our attention towards the challenges of designing multi-purpose VRET-systems. This is important to allow therapists to use VRET in different use-cases and psychological conditions, instead of single anxiety disorder targeted VRET-systems. In addition to looking at individual disorders and VRET solutions, this calls for more holistic approaches identifying general needs and requirements for VRET-systems based in therapeutic practice.

Furthermore, systems must align with the therapist’s current practice and process. VRET-systems are tools therapists can rely on when treating disorders and must, therefore, be designed in a way that supports the therapists to conduct therapies more efficiently. This may also involve the integration in the current infrastructure for documentation purposes.

Concerning patient presence in relation to locomotion in the virtual environment, the small spaces available in therapist’s offices limits natural physical movements. This has implications for the implementation of locomotion as natural walking might not be a viable option. This limitation implies that methods such as (e.g.) walk-in-place or treadmills may be the only options in this context. This might in turn influence the patient’s sense of presence and the implementation may have to balance the de-facto trade-off between high presence and less space demanding locomotion methods.

As regards patient presence in relation to having a virtual representation of the body, we have seen in our studies that this depends on the specifics of the case. In scenarios where the body is used as a mental reference for measurement of distances [26], a virtual body influences presence. In other scenarios without the need to estimate distances a virtual representation appears to have less impact on presence. In our experiments, we found indications that in social scenarios a virtual representation is not of central significance. However, our experiments were conducted with participants without psychological conditions and the results may differ with real patients due to a different perception of the scenario and situation.
5.3 Methodical reflection

Within our interdisciplinary research project we had direct contact to psychologists that helped us to understand exposure therapy and current practice. However, in retrospect, I have to consider the psychologist partners in Paper I and III more as clinical researchers then practicing therapist. A potential problem of this is that previous research [27] has highlighted the importance of integrating practicing therapists that will later use the systems, in addition to clinical researchers. In Paper II this was not an issue as therapists were involved. In conclusion of this aspect, I still consider the feedback, concepts and ideas from the clinical researchers as important and valuable, nonetheless, these systems still needs to be validated with in-practise therapists.

For the patient’s, we conducted exclusively in-lab studies with healthy participants. From an ethical standpoint, this was the best way to evaluate the current state of our systems in this early state of development [5, 7]. At this stage, the main focus is to prove the potential benefits for therapy and our approach follows general recommendations, in this regard. However, this may have influenced results as people with real anxiety disorders may experience the situations, needs, and environments differently. For instance, presence may be influenced for someone who (e.g) have difficulties speaking in front of an audience.

The concept of presence, which was the main focus on the patient’s side because of its importance for VRET [22, 3], is not entirely unproblematic. For instance, it is considered to be too abstract for the participants[40] and contains influencing factors that differ from the individual patient depending on the psychological condition and anxiety [22]. Despite these issues, presence is still considered important as it may influence VRET [22, 6, 3] and it is also an important measure for the VR research community.

We measured presence using different dimensions and strove to avoid interference with the participants experience. Therefore, for in-experiment measures in Paper I, we used observation, physiological recording (heart-rate) and direct assessment (i.e. asking for the level of presence while the participant is immersed). However, after Paper I, we concluded that the direct assessment may have influenced presence, and therefore we did not use this measure in Paper III. Furthermore, since the measurement of the participant’s heart-rate did not provide significant differences in Paper I, this measure was also excluded in Paper III. In Paper III, we instead handed out standard questionnaires to provide a score for presence and combined this with interviews and observations. The downside of this approach, however, that we aimed to overcome in Paper I, is that it may be difficult to recall presence in post [11]. However, since this a common approach in research, this study suffers from similar biases as other studies in the field.
Chapter 6

Conclusion and Future Work

My research aims to contribute to the understanding of exposure therapy and investigate the future role of VR in CBT sessions. In the process, I have striven to integrate therapists in the early design stages of prototypical VRET-part-system that we have developed and evaluated. These systems are early pre-clinical prototypes that explore technological opportunities and challenges for the design of VRET-systems and we have evaluated them with ordinary people without any diagnosed psychological conditions. Although the research conducted scratches the surface of what there is to explore, the results from these studies highlight important challenges for the future development of useful and flexible VRET-systems.

Finally, to conclude the discussion, let us return to the research question:

What are the challenges for designing VRET-system to support therapist’s and patient’s interactions?

In summary, drawn from the discussion and my research I have found several challenges for the development of VRET-systems related to the 1) patients individual therapeutic needs, 2) required flexibility of the system to support role-play and multiple scenarios, 3) the complexity of integrating multiple rich interactions and the scalability of functionality, 4) visibility of system status in complex VRET-systems 5) developing scenarios that evoke a high presence, and 6) supporting patient locomotion in small rooms.

First, patient’s and their conditions are highly individual, requiring the therapist to customize sessions in terms of scenarios and details. Therefore, and secondly, it is important that VRET-systems support many different scenarios and that each scenario provides a high degree of flexibility and customization in order to support the individual character of therapy. Thirdly, this leads to a scalability challenge of creating rich VRET-systems with many functions. In the studies presented in this thesis we evaluated seemingly simple interactions that are not sufficient to support the needs for flexibility and customization. However, these interactions still
turned out to be non-trivial causing us to realize that the usability and complexity of the system will be a grand challenge as we start to add on new possibilities and interactions. For instance, and fourthly, the HCI usability concept of visibility of system status will be a difficult challenge as the therapist gets increasing control over vast numbers of details in the VR environment and is responsible for orchestrating the narrative unfolding during the sessions. Fifthly, patient’s presence is an influencing factor for the success of a therapy in VR and, therefore, VRET-systems must provide highly present scenarios. To achieve this, we have to design systems that manipulate the influencing factors of presence. Finally, one influencing factor is the possibility to move within VR, called locomotion, challenges VRET-systems. Therapy rooms typically are small and some mental conditions and scenarios require the patients to move within the VR environment. This emphasises the challenge of supporting locomotion in small physical spaces, which is a challenge addressed in research on locomotion methods such as WiP [43] or treadmills [46].

To conclude, I have identified a number of challenges relevant for future research on VRET-systems and on a meta level I like to highlight that there is a need to conduct more research on the needs of therapists and how we can support rich and flexible therapeutic sessions using VRET-systems.

6.1 Potential Future Work

In my future work I aim to continue to address and involve both, therapists and patients. However, since we have not yet evaluated the systems together with therapists, this is important first step to complete development process of technology for mental health [5]. In the evaluation, the preliminary plan is to use a role-playing approach [7] as the system is not ready for clinical trials, yet.

To continue with the learnings presented in this thesis, I intend focus more on the challenges around rich interaction, in contrast to more simplistic VRET-systems, that provide improved flexibility and support therapist-patient role-play. A potential case with a social orientation could be oral exams or job interviews. These settings distinguish from the evaluated scenario described in Paper III (public speaking anxiety) in the closeness of the interaction. In Paper III, the presenter stands at a larger distance to the audience compared to a face-to-face conversation. Here we could investigate aspects of close interaction and the influence of communication-related concepts such as eye-contact and body language.
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