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EXPLORING VIRTUAL SOCIAL ENVIRONMENTS FOR EXPOSURE THERAPY IN ADOLESCENTS WITH SOCIAL ANXIETY

A Pilot Study

M.Sc. Thesis
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ABSTRACT

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Social anxiety disorder (SAD) is a prevalent mental health condition that often begins in childhood or adolescence and can persist into adulthood if untreated. Virtual reality exposure therapy (VRET) has proven to be an effective and acceptable intervention. However, the use of social settings such as restaurants and cafeterias in VRET targeting adolescents is rare. This study aimed to evaluate the feasibility of a 3D Virtual Reality (VR) restaurant-themed application prototype. The application is designed with three exposure levels (mild, moderate, and intense) as a therapeutic tool for clinical use. The objectives were to determine whether the application could provide stimuli to induce anxiety necessary for exposure therapy and evaluate the user experience.

Eleven young participants, mostly socially anxious, evaluated the VR prototype, providing both quantitative and qualitative data through the Subjective Units of Distress Scale (SUDS), the Igroup Presence Questionnaire (IPQ), the User Experience Questionnaire Plus (UEQ+), and a semi-structured interview. The VR prototype induced varied anxiety levels, with minimal anxiety reported at the Intense level and mild-to-moderate anxiety prevalent across all exposure levels.

Participants experienced a high sense of general presence despite lower realism in their VR experience. While the exposure levels had an impact on participants' subjective anxiety, no effect of presence was observed. The prototype had higher ratings for usefulness in the user experience evaluation, though visual aesthetics received the lowest ratings.

The study findings emphasise the potential of VRET for social anxiety disorder treatment and highlight key design considerations for implementing exposure hierarchy for more anxiety-inducing effects.

Keywords: social anxiety disorder, virtual reality, exposure therapy, VR, VRET, mental health, adolescents

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PREFACE

All praises to the Almighty for guiding me through this journey, which once seemed daunting, to a successful conclusion. My heartfelt appreciation goes to my family, friends, and colleagues, whose prayers, encouragement, and kind words made this academic experience worthwhile, especially when challenges arose.

I want to express my gratitude to my supervisors, Prof. Markku Turunen and Prof. Kaija Puura, as well as nurse Kolehmainen Kimmo from the Tays Adolescent Psychiatric Clinic, for their support and for giving me the opportunity to pursue my master's thesis in a health-related area. Special thanks to the ITC faculty staff, particularly Kimmo Ronkainen, John Mäkelä, Bojan Kerous, and Prajwal DSouza, for their technical assistance during the VR prototype development phase. Likewise, I recognise the support received from my post-doctoral researcher friends, Mahmud, Yusuf, and Abdullahi.

This thesis tested me on a whole new level, from becoming a VR developer and 3D character animator within a short period while at the same time acting as the sole researcher. Not to mention the challenge of recruiting young participants. Despite the struggles, I embrace the learning opportunities and see them as necessary for my growth as a User Researcher.

This project holds special significance for me due to my personal experiences with social anxiety. I hope that this work contributes meaningfully to mental health research and offers insights to medical professionals, application developers, kids with this condition, and their families, helping them access the care they need to lead fulfilling and productive lives.

Tampere, 29 October 2024

Fareed Gbolaniyi Agbaje

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LIST OF SYMBOLS AND ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
ADIS	Anxiety Disorder Interview Schedule
ASD	Autism Spectrum Disorder
CBT	Cognitive-Behavioural Therapy
CGI	Computer-Generated Imagery
CSR	Clinician Severity Rating
DAWBA	Development and Well-Being Assessment
DISC	Diagnostic Interview Schedule for Children
DSM	Diagnostic and Statistical Manual
FNE	Fear of Negative Evaluation
FPS	Fear of Public Speaking
HMD	Head-Mounted Display
IPQ	Igroup Presence Questionnaire
K-SADS	Kiddie Schedule for Affective Disorders and Schizophrenia
LSAS-CA	Liebowitz Social Anxiety Scales for Children and Adolescents
OCD	Obsessive Compulsive Disorder
PARS	Paediatric Anxiety Rating Scales
PE	Prolonged Imaginal Exposure
PSA	Public Speaking Anxiety
PTSD	Post-traumatic Stress Disorder
RCT	Randomised Controlled Trial
SAD	Social Anxiety Disorder
SAS-A	Social Anxiety Scale for Adolescents
SAS-C	Social Anxiety Scale for Children
SASC-R	Social Anxiety Scale for Children-Revised
SET-C	Social Effectiveness Therapy for Children
SNRI	Serotonin-Norepinephrine Reuptake Inhibitors
SPAI-C	Social Phobia and Anxiety Inventory for Children
SPIN	Social Phobia Inventory
SQOL	Inventory of Subjective Life Quality
SSRI	Selective Serotonin Reuptake Inhibitors
SSRS-A	Social Support Rating Scale for Adolescents
SUDS	Subjective Units of Distress Scales
UEQ	User Experience Questionnaire
VR	Virtual Reality
VRET	Virtual Reality Exposure Therapy
VRT	Virtual Reality Technology
WHOQOL	World Health Organisation Quality of Life

1. INTRODUCTION

Social Anxiety Disorder (SAD) or social phobia is a mental health condition relating to a person perceiving social situations, such as interacting with other people, mostly unfamiliar in fear. According to the World Health Organisation (2023), SAD is one of the world's most common mental health disorders. Social phobia is characterised by intense fear or discomfort in social situations. This fear can be limited to one specific situation, such as eating in front of others or can occur in broader situations in general social settings. Individuals with this type of anxiety fear embarrassment in these situations, which often include fear of being ridiculed, laughed at or disliked by peers (Crozier et al., 2011, p. 11). SAD can significantly impair individuals' functioning in work, school, and relationship contexts (Aderka et al., 2012).

In children, SAD symptoms typically persist for at least six months, leading to significant interference in social functioning (American Psychiatric Association [APA], 2013). These symptoms can result in the child refusing to go to school or participate in family social activities. Social phobia in children and adolescents, if not promptly addressed, can lead to long-term adverse effects, including developing the habit of substance use (Marmorstein et al., 2010), negatively affecting their psychological development, professional life, and contribution to society.

Exposure-based therapy is the gold standard treatment for anxiety disorders such as specific phobia, social anxiety, posttraumatic stress disorder (PTSD), and obsessive-compulsive disorder (OCD) (Steinman et al., 2016). It is a psychological treatment that helps people face and overcome the things, activities, or situations that cause them fear or anxiety by confronting those situations. By confronting their fears rather than avoiding them, patients gradually observe a reduction in their anxiety and fear, allowing them to develop effective strategies to manage their emotional reactions. Existing research (Ramsey et al., 2023; Khan et al., 2021; Wang et al., 2021) shows that exposure therapy can be an effective and efficacious treatment for children and adolescents with anxiety disorders. Therefore, exposure therapy is recommended as a first-line treatment for youngsters (Walter et al., 2020).

Stefaniak et al. (2022) note three approaches to implementing exposure therapy for persons suffering from social anxiety disorders: in vivo exposure, imaginal exposure, and

virtual reality exposure. The first involves exposure to the actual fear in real life, the second involves the individual using imagination to recreate their feared situation, and the third involves exposure to the fear in a simulated virtual environment. Despite the efficacy of the first two exposure therapy methods, in vivo and imaginal, some exposure stimuli or social situations may be challenging to replicate or set up in a therapist's office. For instance, Ramsey et al. (2023) pointed out that setting up a public speaking exposure with an audience of 50 strangers for youth experiencing social anxiety may be impossible for a clinician in an outpatient setting. The third approach, virtual reality exposure, provides the accessibility and personalisation for different situations necessary to create stimuli needed for patient treatment.

Exposure therapy delivered through virtual reality technology (VRT), referred to as Virtual Reality Exposure Therapy (VRET), has been reported as a promising and potentially valuable option for the treatment of various mental health disorders (Riva & Serino, 2021; Maple-Keller et al., 2017). By using technology to mimic real-world scenarios in a controllable environment, different social settings can be created and exposed to the patient, such as classrooms, parties, and public speaking situations. With the rapid advancements in technology, the quality of images produced in the virtual environment keeps improving, and the cost of acquiring the gadgets is reducing. Hence, VR is becoming a less expensive and accessible alternative mode of treatment compared to traditional psychotherapy.

In the research space, the use of VR as an exposure therapy for social anxiety disorder has primarily targeted the adult population, with fewer studies examining its application for children and adolescents (Shahid et al., 2024). Possible reasons for this may be due to ethical issues and concerns for the overall development of this young population with their use of modern technologies, as brought up by Kaimara et al. (2022). Furthermore, a review of existing literature on the use of social settings, such as restaurants and cafeterias in VRET aimed at adolescents, reveals limited research.

The potential benefits of VRET for both therapists and patients have been recognised in earlier studies. This thesis explores the feasibility of implementing VR exposure therapy at Tampere University Hospital (Tays) Adolescent Psychiatric Clinic as a supplement treatment for youngsters with social anxiety disorder. The decision to use a restaurant-based virtual environment for exposure therapy is based on practical and developmental considerations. While the frequency of visits and access to restaurants may vary among adolescents due to socioeconomic factors, cultural backgrounds, and individual preferences, these settings still hold significant importance. Restaurant scenarios play an

important role in social skills development and exposure to anxious encounters. For one, restaurant settings present social environments involving multiple anxiety-triggering situations for individuals with SAD, such as eating in public, interacting with peers and strangers (e.g., the attendants), and facing possible scrutiny from others. Moreover, the activities performed in restaurants, such as ordering food, engaging in conversations, navigating spaces, and handling money are skills useful in other social contexts. In addition, the use of a three-dimension (3D) environment for exposure therapy allows for user engagement and performance of activities, making the interaction dynamic and the experience more immersive.

The purpose of this thesis was to obtain and analyse primary data to understand whether virtual social environments, such as restaurants or cafeterias, with specific stimuli present, affect anxiety levels and whether such environments could be used for exposure therapy before real-life exposures as part of the treatment process.

For this thesis, a 3D virtual reality application prototype depicting a fast-food restaurant was developed with three exposure levels: Mild, Moderate, and Intense. The prototype was designed to simulate social situations and enable interaction. The prototype offers a prudent way of assessing the virtual environment's applicability. Evaluations such as this can be done before making significant financial investments in acquiring more advanced, commercially available VRET-tailored applications. The results of the evaluation could be considered for future applications.

An experimental study was conducted to address the following research question (RQ):

RQ: "To what extent can the developed 3D VR restaurant prototype provide stimuli to induce anxiety or distress during exposure?"

Adapting terminologies from the famous IDEO's Desirability, Viability, and Feasibility (DVF) framework, the study had two objectives:

1. Feasibility: To explore the feasibility of the VR application prototype, i.e., the prototype's capacity to induce anxiety

2. Desirability: To evaluate the user experience, assessing the acceptability of the prototype and noting areas for improvement

The author hypothesised that participants would report some level of subjective distress during exposure to the VR application, although the extent was uncertain. If supported,

the hypothesis would inform future research concerning the development of virtual social environments for SAD aimed at adolescents.

In the study, a subjective minimal anxiety/distress was observed at the Intense level, and mild-to-moderate anxiety was recorded across all levels. Participants reported having a high sense of general presence but low realism in their VR experience, as assessed by the Igroup Presence Questionnaire. It was found that the effect of the exposure levels on subjective anxiety levels was significant; however, none was found for the sense of presence. The VR application's usefulness received the highest ratings, while the visual aesthetics received the lowest ratings in the user experience evaluation. These findings stress the potential of VR exposure therapy in providing controlled stimuli for SAD treatment. Key aspects, such as visual appeal and interaction capabilities, were also identified, which should be further investigated and improved in the design of VRET systems to meet therapeutic goals.

The thesis structure is presented as follows: firstly, in Chapter 2, "Theoretical Background", a review of existing literature on social anxiety disorder and the application and feasibility of virtual reality for social anxiety and related disorders treatment are discussed. Chapter 3, "Methodology and Materials", gives details of the materials and methods used in the study. Specifically, it focuses on the VR prototype development, the user study design, participants' demographics, measures used, procedures of the experiment, and data analysis methods. In Chapter 4, "Results", an explanation of the results of the study is given. The main findings of the study, its implications for VRET systems design, and limitations are discussed in Chapter 5, "Discussion". Lastly, the conclusion of the paper, summarising the study findings and suggestions for future research, is presented in Chapter 6, "Conclusion".

2. THEORETICAL BACKGROUND

This chapter examines existing literature on social anxiety disorder and its treatment, with an emphasis on VR applications. Section 2.1 defines social anxiety disorder and explores its developmental risk factors specific to the younger population. Section 2.2 discusses the prevalence and impact of the disorder in children and adolescents. In Section 2.3, various methods for assessing SAD symptoms are described. Section 2.4 outlines the two treatment approaches for SAD: pharmacotherapy and psychotherapy. Exposure-based treatments are introduced in 2.5, comparing Virtual Reality Exposure Therapy with traditional exposures. Section 2.6 discusses the role of VR in clinical practice, and its implications on child development are presented in Section 2.7. 3D and 360° video virtual social environments are explored in Section 2.8. VRET for SAD and related mental health conditions are discussed in Section 2.9. Lastly, Section 2.10 explores studies of VRET assessments and treatments aimed at children and adolescents.

2.1. Social Anxiety Disorder: Definition and Development Factors

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013) defines social anxiety disorder with nine criteria: (1) marked, or intense fear or anxiety of social situations in which the individual may be scrutinised by others. In children, the fear or anxiety must occur in peer settings and not just during interactions with adults; (2) the fear or anxiety is out of proportion to the actual threat posed by the social situation and to the sociocultural context; (3) the social situations almost always evoke fear or anxiety; (4) the child or adolescent avoids or endures the social situation with intense fear or anxiety; (5) when exposed to these situations, the child or adolescent experiences clinically significant distress or impairment in social, occupational, or other important areas of functioning; (6) the fear lasts for at least six months; (7) the fear, anxiety or avoidance cannot be attributed to effects caused by drug use or another medical condition; (8) the emotional distress is not better explained by symptoms present in other mental disorders; (9) if another medical condition is present in the individual, the distress is not related or is more.

The revision of the DSM-5 (APA, 2013) included a SAD specifier that denotes “performance only” fears (APA, 2013, p. 203), such as public speaking. Individuals with the performance-only type of SAD typically are most impaired in professional lives (e.g., musicians, dancers, performers, athletes) or work, school, or academic settings requiring

regular public presentations. These individuals are not fearful of or avoid social situations that do not involve performance.

In an updated meta-analysis by Spence and Rapee (2016), factors contributing to the development and maintenance of SAD, children inclusive, were examined. Two groups of factors were identified: intrinsic and extrinsic. Related to intrinsic factors, there are links of SAD development related to genetics, biological influences, temperament, cognition, safety behaviours, and poor social performance. According to the reviewed studies, evidence shows that children whose parents had SAD have a higher risk of developing the condition. Likewise, parents of children with SAD may experience the condition as well. Earlier brain imaging studies between socially anxious young people and their non-socially anxious counterparts show increased amygdala activation in the brain in response to social threats. Children with behavioural inhibition temperament are at a greater risk of developing SAD. More negative expectations of social tasks, one's own performance evaluations, and pre- and post-event processing are evident in children and adolescents with high social anxiety. Furthermore, as a way to remove themselves from social situations, children with SAD adopt behaviours such as avoiding eye contact and speaking less.

A few external factors have been reported to influence the risk of SAD in young people, as examined by Spence and Rapee (2016). These factors include peer relationships, parenting styles, and traumatic life experiences. Particularly in school environments, negative social experiences with peers, such as teasing, bullying, and performing in front of the class, can lead to fear and avoidance, thereby increasing the risk of social anxiety. Parent styles involving threat, over-protection and control could also heighten the development of the condition. The experience of adverse life events during childhood, such as abuse of all forms, family issues (separation, neglect, discord, violence), and illness, may contribute to the manifestation of SAD. The findings emphasise the role biological, psychological, and environmental factors play in the onset of social anxiety in young individuals.

2.2. Prevalence and Impact of Social Anxiety in Adolescents

Social anxiety disorder is one of the most common anxiety problems in adults as well as youth. A meta-analysis of the global prevalence of social anxiety disorder by Salari et al. (2024) found that the prevalence was estimated to be 4.7% in children, 8.3% in adolescents, and 17% in young adults, suggesting a rise in SAD as individuals transition through these developmental stages. A gender difference is also clearly visible in

adolescents with social anxiety. The study by Ranta et al. (2024) on social anxiety symptoms prevalence in young Finns aged 13 - 20 from 2013 to 2021 reported higher rates in females (32.7%) compared to males (17.1%). For adolescents, social anxiety impacts different areas of their lives, including school withdrawal, getting lower grades, having fewer friends and quality relationships, and poor social skills. Besides, youths face the risk of becoming victims of bullying (Acquah et al., 2016). The situation may grow with them into adulthood, further impairing their quality of life.

Two studies examined the impact of social anxiety on the quality of life in school-age youths. In the first study, Alsamghan (2020) assessed the presence of social anxiety symptoms and their impact on the quality of life among students in four Saudi Arabian secondary schools. The researchers used the Social Phobia Inventory (SPIN) and World Health Organisation Quality of Life (WHOQOL) questionnaires. The study results revealed that almost half (45%) of the participants showed SAD symptoms, and some contributing factors included personal health conditions, family income and status. Additionally, the quality of life was significantly lower in participants with social anxiety symptoms across the domains of physical health, environment, social relationships and psychological health.

In a similar localised study, Yang and Lu (2022) investigated the relationship between social anxiety, subjective quality of life, and the role of social support among left-behind children in five Chinese junior high schools. Assessment measures included the Social Anxiety Scale for children, the Social Support Rating Scale for Adolescents, and the Inventory of Subjective Life Quality (SQOL). Results showed that higher social anxiety levels were associated with lower SQOL levels, and an increase in social support positively correlated with higher levels of SQOL. The outcomes of both studies suggest the need for support and adequate management to improve the quality of life of affected youths.

Despite the prevalence and impact of SAD, the disorder often goes unnoticed and untreated, partly because it is underestimated by parents and teachers (Masia et al., 2001). Social anxiety disorder usually coexists with other mental health conditions, including other anxiety disorders, mood disorders, major depressive disorders, and substance use disorders, with SAD typically preceding the onset of these other conditions (DSM-5; APA, 2013). Koyuncu et al. (2019) noted that this comorbidity leads to difficulties in diagnosis and treatment, making assessment key for early detection and effective intervention.

2.3. Assessment of SAD Symptoms

As social anxiety is a widespread condition, careful and thorough assessment is essential for effective treatment planning. Various assessment methods have been developed to diagnose the presence and severity of social anxiety in adults and children. Some of these methods include clinical interviews, interviewer-rated scales, self-report questionnaires, self-monitoring techniques, and thought-listing procedures (Herbert et al., 2014).

2.3.1. The Clinical Interview

The clinical interview is by far the most common assessment method for SAD and is the first point of contact between the patient and the therapist or researcher (Herbert et al., 2014, p. 46). The interview has three goals: (1) establishing rapport, (2) ensuring an accurate diagnosis, and (3) assessing symptom patterns, phobic stimuli, and impairment in functioning.

Herbert et al. (2014) recommend seven strategies for interviewing individuals with social anxiety. They advised clinicians to start with small talk as an icebreaker and use a mix of open- and closed-ended questions while maintaining a slow pace without an interrogative tone. The interviewer should avoid showing disapproval of patients' statements, and with children or adolescents, it may help to begin with a naturalistic activity outside the consultation room. Additionally, gathering information from parents and teachers can be valuable for the interview process. Herbert et al. (2014) also noted that clinical interviews can either be unstructured or structured – the former are common in clinical practice while the latter are more appropriate for research due to their higher diagnostic rates for SAD (pp. 47-48).

Wong et al. (2016) conducted a review of clinician-administered and self-report scales used for diagnosing and measuring symptoms of SAD. For youths, two widely used semi-structured interviews are the Anxiety Disorder Interview Schedule for DSM-5 (ADIS-IV) and the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS). The ADIS-IV, now revised to ADIS-5, includes parent and child versions (ADIS-5 P/C), which allow clinicians to rate the severity of SAD using a Clinician Severity Rating (CSR). The social phobia module in these interviews includes presence or absence ratings of avoidance and symptoms. Both ADIS and K-SADS require separate interviews with the child/adolescent and parent that the clinician relies on to make a diagnostic decision.

In the same study, Wong et al. (2016) examined two popular structured interviews for SAD in youth: The National Institute of Mental Health Diagnostic Interview Schedule for

Children IV (DISC-IV) and the Development and Well-Being Assessment (DAWBA). Similar to the semi-structured interviews, the DISC-IV includes parent and youth versions and the social phobia sections. The authors identified a major challenge in diagnostic interviews for youth, which is the frequent inconsistency between parent and child reports. They further explained that in most cases, the parent-reported symptoms hold more weight since the reports are based on observations rather than feelings.

2.3.2. Interviewer-rated Scales

Numerous rating scales have been developed for measuring the severity of SAD symptoms, with different consistency and stability reported. The Paediatric Anxiety Rating Scales (PARS) and the Liebowitz Social Anxiety Scales for Children and Adolescents (LSAS-CA) are two useful clinical-rated instruments for assessing SAD in youth (Wong et al., 2016). The PARS consists of 50 items that assess the severity of anxiety symptoms of SAD, including other anxieties identified in the DSM-5 within the past week. The scale is administered to both children and their parents individually (Freidl et al., 2017). The LSAS-CA, adapted from its adult version, measures anxiety and avoidance of interaction and performance in social situations involving children, such as responding to questions in the classroom or participating in social activities. The instrument is also known to have higher accuracy in identifying the presence of social anxiety (Wong et al., 2016).

2.3.3. Self-report measures

The use of self-report questionnaires in the assessment of social anxiety has many benefits, such as efficiency, repeated use for treatment effects, easy data comparison, and less time required to administer and score (Herbert et al., 2014). Several children and adolescents self-report measures have been developed and validated to assess symptoms of social anxiety. Common measurement scales include the Social Phobia and Anxiety Inventory for Children (SPAI-C), the Social Anxiety Scale for Children-Revised (SASC-R), the Social Anxiety Scale for Adolescents (SAS-A), Social Phobia Inventory (SPIN), and the LSAS-CA (Wong et al., 2016). The SPAI-C is a 26-item scale measuring SAD symptoms based on the DSM criteria and assesses responses across different age-relevant social settings. Both SASC-R (22-item) and SAS-A (18-item, original version) assess the fear of negative evaluation (FNE), social avoidance and distress in new situations or with unfamiliar peers, and general social avoidance and distress.

2.4. Treatment Approaches

Treatments for SAD include both psychotherapy (psychological approaches) and pharmacotherapy (pharmacological approaches). The treatment decision is dependent on a thorough clinical assessment of the patient, their choice, recommendations from clinicians, and other factors.

2.4.1. Pharmacotherapy

Blanco et al. (2014) provided evidence to demonstrate that pharmacological approaches to social anxiety disorder can substantially reduce avoidance and psychological distress. Powers et al. (2014, p. 755) argue that in contrast to cognitive behavioural therapy (CBT), pharmacological interventions aim to directly target the biochemical pathways responsible for anxiety triggered by disorder-specific cues such as social scrutiny in SAD.

The use of medications such as selective serotonin reuptake inhibitors (SSRIs) and serotonin-norepinephrine reuptake inhibitors (SNRIs) are first-line treatments for SAD (Bandelow et al., 2017; Blanco et al., 2013). For children and adolescents, however, nonpharmacological approaches are preferred (Creswell et al., 2014), even though studies have shown efficacy of the above-mentioned medications.

Strawn et al. (2023) examined the adverse effects of antidepressant medications and their management in children and adolescents, assessed using physical symptoms checklists. In the review, Strawn et al. (2023) identified several side effects that surface early during treatment, such as activation, gastrointestinal symptoms, insomnia, fatigue, and sedation. Side effects such as weight gain, headaches, increased sweating, vivid dreams, and sexual dysfunction occur much later. Similarly, there are withdrawal symptoms when medications are suddenly discontinued. They recommend that clinicians should discuss the potential side effects of the medication with patients and their families prior to treatment, and for managing withdrawal caused by antidepressants, adherence to dosage and slowly discontinuing the medication were suggested.

2.4.2. Psychotherapy

The current psychosocial treatment of choice for SAD is cognitive behavioural therapy, a family of learning-based approaches that help patients eliminate the core fears, associated avoidance, and anticipatory anxiety in anxiety disorders (Powers et al., 2014, p. 753). Otto et al. (2004) emphasised that the focus of CBT is helping patients relearn a sense of safety rather than simply coping with feared situations and events. According

to Rowa et al. (2014, p. 498), CBT for SAD includes core strategies, such as psychoeducation, behavioural experiments, cognitive strategies, exposure-based strategies, social skills training, applied relaxation, and other methods.

de Ponti et al. (2024) conducted a meta-analysis of 66 studies involving 5,560 participants, revealing numerous findings about the efficacy of psychotherapy treatments for SAD symptoms. Large effects of the therapy approach were observed for all types of psychotherapy, including CBT and exposure, and delivery formats, such as individual, guided, and group-based. This finding, in particular, suggests that different forms of psychotherapy are acceptable treatment options and could be tailored to patient preferences, further improving the willingness to seek and receive treatment. In addition, they found significant effects of guided and group self-help treatment delivery formats in reducing symptoms. Furthermore, the analysis found sizeable effects of psychotherapy in clinically recruited participants compared to those recruited via other affiliations, supporting the importance of clinical assessments. While the study reported the effects of unguided self-help as being minimal, the authors proposed that the treatment option may be a viable choice in areas where mental health facilities are inaccessible.

2.5. Exposure-based treatment

Exposure is one of the key treatment ingredients leading to symptom improvement for SAD (Khan et al., 2021). The goal of exposure-based treatment for SAD is to educate individuals so that they can face their fears of embarrassment and negative evaluation. Further, the treatment mode allows the patient to cope with the discomfort associated with the anxiety rather than just avoiding it, which provides no benefit in the long term. By confronting the feared stimuli or responses and integrating corrective information in the fear memory, fear is expected to decrease (Kaczkurkin & Foa, 2015).

The American Psychological Association (APA, 2017) highlights various forms of exposure therapy and their pace of delivery. For the exposure forms, they include in vivo, imaginal, virtual reality, and interoceptive exposure. The delivery pace can be done through graded exposure, flooding, or systematic desensitisation.

Although exposure-based treatment is regarded as effective in reducing reactions to feared situations, this therapy approach is less used in clinical practice (Pittig et al., 2019). Many adults, youths, and children with anxiety disorders do not receive exposure-based treatment, or there is less use of it for their case. The study by Wolitzky-Taylor et al. (2015) involving a large community mental health centre revealed that nearly 90% of

their patients received drug treatments while only less than 4% benefited from exposure-based treatment for their anxiety disorder. de Jong et al. (2020) highlighted some reasons for the underutilisation of exposure therapy, such as therapists' negative beliefs about exposure-based therapy, therapists' age, and lack of CBT orientation. Patients' perceived threat of direct engagement and real-life confrontation with the feared stimuli could also be a factor, given that health professionals are obligated to respect patients' concerns and preferences in treatment decisions.

2.5.1. Virtual Reality Exposure vs Traditional Exposures

In vivo exposure, a form of traditional exposure therapy, involves an individual physically confronting their feared situation. This exposure is regarded as more effective for treating phobias such as public speaking (Reeves et al., 2022). However, virtual reality could increase the acceptability of exposure-based treatments for patients seeking and receiving treatment (Scheveneels et al., 2023). To corroborate this claim, Scheveneels et al. (2023) examined the acceptability of virtual reality and in vivo exposure treatments among 186 fearful participants. They found that virtual reality exposure was considered more acceptable (58%) and associated with fewer negative beliefs than in vivo exposure therapy (35%).

The survey conducted by Levy et al. (2023) involving 184 respondents explored the perceptions of individuals with anxiety disorders regarding both in vivo exposure and VRET. The findings revealed that participants were slightly more inclined to opt for VRET (90.2%) over in vivo exposure (82%). They also expressed higher levels of interest, comfort, enthusiasm, and perceived effectiveness for VRET. Despite these preferences, concerns were raised for both methods. For in vivo, concerns included heightened anxiety, embarrassment, and worsening of conditions. For VRET, participants cited concerns about side effects, uncertainty surrounding its effectiveness, and issues related to health insurance coverage. Nonetheless, participants professed several advantages of VRET, such as increased privacy, safety, exposure control, comfort, lack of real-world consequences, effectiveness, and adaptability to a wider range of exposure scenarios.

In addition, the possibility of targeting specific cognitive systems of interest to specialist therapists makes VR beneficial over other traditional exposures. Riva et al. (2015) cited different therapists' use cases for VR exposure. For example, a behavioural therapist may use a virtual environment to activate fear responses in fearful patients through confrontation with the feared stimuli. Cognitive therapists may apply VR situations to assess situational memories or alter patterns of selective attention in patients. An experiential

therapist may adopt VR to help patients practice certain actions by isolating them from the physical world. Psychodynamic therapists may leverage virtual environments as complex symbolic systems for evoking and releasing effects (p. 288).

Cost is another aspect where VR proves beneficial over in vivo and imaginal exposures, as described by Riva et al. (2015). In vivo often necessitates multiple visits by the therapist to the feared place. Still, therapist-absent exposure treatment, though available, is scarce, and patients are hesitant to participate in such interventions. Sometimes, the location is also inaccessible. Furthermore, imaginal exposure is less effective and can be impaired by individual patients' imaginative abilities to recreate the feared situation. VR can address these challenges through the generation of different settings, which would otherwise be impossible within the therapist's office (p. 293). Moreover, VRET can make exposure therapy well-suited for patients and the clinicians administering treatments, particularly in the aspects of changing the VR experience in real-time with the use of data gathered by sensors which record patients' reactions via signals (Ferreira et al., 2022).

Finally, treatment discontinuation can be lesser in VRET when compared to in vivo as exposure to social situations is done virtually rather than in real life (Emmelkamp et al., 2020). These advantages of VR offer a promising option to enhance the implementation and effectiveness of exposure therapy, improving patient engagement and treatment outcomes.

2.6. Virtual Reality in Clinical Practice

In recent times, VR technology has gained traction within clinical research circles as a viable alternative for treatment. Riva (2022) provides an overview of VR's role in clinical practice. From a technical perspective, VR consists of a set of technologies, including computers with (3D) visualisation capabilities, controllers and a head-mounted display (HMD) equipped with trackers to view computer-generated environments.

Schultheis and Rizzo (as cited in Riva, 2022) define VR as an advanced form of human-computer interface that allows users to immerse themselves in and interact with a computer-generated environment in a natural way. VR, a form of media, is distinguished by its *sense of presence*, a concept described as the extent to which an individual perceives being in a virtual environment (Slater & Sanchez-Vives, 2005) and is an important aspect of VR experiences.

As described by Riva (2022), VR technology can be categorised into two types: immersive and non-immersive. Immersive VR systems mostly use HMDs to separate the user from the physical world, replacing their view with that of the computer-generated environment, and adapting the environment to the user's perspective. Non-immersive VR systems, on the other hand, use high-resolution screens to present the virtual environment to the user without fully occluding the user's physical view and offer less interaction capabilities.

According to Riva (2022), usability and cost of VR systems have been the main obstacles for VR applications in clinical practices. Older generation of VR devices were heavy, expensive, uncomfortable to use, and required technical expertise for the environment design and operation. However, advancements in VR technology have led to the development of more affordable, compact, and user-friendly systems. Modern VR systems, in addition to visual and auditory feedback, can provide olfactory and haptic responses.

Riva (2022) identifies three technological characteristics of VR as an effective clinical tool: simulative, cognitive, and embodied. Firstly, as VR is used to simulate scenarios of the physical world in the virtual environment, it is suitable for experiential learning, where patients learn by doing. Likewise, it has emotional response-inducing effects. VR is a cognitive technology that provides users with the ability to manipulate and explore the virtual world as if they are physically present in it. This attribute makes it possible to predict human sensory reactions similar to the real world if experienced. Lastly, the ability of VR technology to make individuals perceive virtual experiences as real offers innovative ways for clinical research to further improve health and wellbeing through structured, augmented, and/or replaced body experiences.

Maples-Keller et al. (2017) outline the treatment course to achieve effective VR exposure therapy. The initial sessions include psychoeducation, relaxation techniques, psychosocial and avoidance behaviour awareness. The concepts of exposure therapy are also introduced before discussing the process of the VR-based exposures. In subsequent sessions, the patient is exposed to the VR-based intervention and allowed to progress at their own pace. In quality VREs, exposure hierarchy needs to be personalised such that patients can be repeatedly exposed to the feared stimuli until anxiety decreases. Additionally, the VR content should match the patient's fear hierarchy. Furthermore, the therapist needs to work closely with the patient to activate the fear structure while encouraging emotional engagement during the VR exposures. They also discuss the importance of avoiding safety behaviours to ensure the patient fully experiences the exposures.

Many studies, including clinical randomised controlled trials (RCTs), some of which are described later in subsequent sections support the potential for VR as a viable clinical tool. Newer generations of VR systems which are low-cost, commercially available, and smartphone-compatible makes the development of self-help VR applications feasible, further expanding the access to mental health treatment.

2.7. Implications of VR in Child Development

With the adoption of emerging technologies, there arises ethical issues and concerns that can affect the user or their environment. VR is no exception, especially when it involves children and adolescents. The possible worries of parents, educators, medical professionals, and the technology industry's contributions require attention. Kaimara et al. (2022) extensively examined the impact of VRTs on child development across the physical, cognitive, and psychological domains, also noting that bioethics of human research was a key research problem.

Regarding the domain of physical development, most concerns were related to cybersickness, visual symptoms, obesity, radiation, cardio-metabolic deficiencies, and sleep disorders. Some of these risks develop as a result of others already manifested. For instance, obesity can lead to sleep disorders. In the case of cybersickness associated with the use of virtual environments in HMDs, large screens, and curved systems, its symptoms include nausea, dizziness, and temporary loss of focus. However, these side effects wear off after a while once out of the virtual world. Roettl and Telutter (as cited in Kaimara et al., 2022) found VR to cause higher levels of dizziness and motion sickness compared to 3D and 2D games. A major worry was the effects of VR on children's visual systems, particularly its impacts on the visuomotor system, accommodation, vergence, stereoscopic vision and visual-motor coordination. Myopia, a common vision condition, is not only caused by the use of screens, but also activities performed close to the eyes, including reading physical books, may affect vision (American Academy of Ophthalmology, as cited in Kaimara et al., 2022).

As discussed by Kaimara et al. (2022), the problem of obesity is far more than a consequence of using VRT, as it relates to living a sedentary lifestyle, although the time spent on digital technology can contribute. Many games developed in VR encourage players to engage in physical activities, thus preventing the development of obesity. The authors stated that the use of computers with bright screens at night has been shown to negatively affect sleep, and less sleep could lead to obesity and vice-versa. Another identified risk to children is radiation resulting from constant exposure to wireless devices,

including VR. However, the authors clarified that radiation-related health risks are still unclear due to a lack of research information. Suggested approaches to addressing these concerns include having breaks between sessions to ease the side effects, limiting screen time, restricting device use, and adult supervision.

Kaimara et al. (2022) presented possible risks of VRTs' impact on children's mental abilities, i.e., cognitive development arises in areas such as attention, learning, and both spatial and general cognition. While studies and surveys offer evidence that the use of digital media, particularly with games, can promote positive learning outcomes, research on the learning effectiveness of 2D and 3D displays revealed that the former is considered more effective. One study argues that non-immersive VR systems such as 2D help to improve students' learning achievements, motivation and problem-solving, while another claims realism, a component of VRT, is not promising for games aimed at improving learning outcomes. Conversely, according to Kaimara et al. (2022), a number of studies they cited conclude that 3D simulated environments are effective in altering children's learning outcomes. Those studies investigating VR use by children with Autism Spectrum Disorder (ASD) provide evidence that VR promotes learning outcomes, reduces disruptive behaviours, social anxiety and fosters collaborative learning in classrooms. Another area of concern is the potential confusion for children to mix the virtual and real world. In this case, adults play an important role in helping children distinguish between real and virtual worlds. Additionally, caution should be taken regarding the overuse of virtual environments for children during their development period.

For psychological development, Kaimara et al. (2022) identify the main worries to be about addiction, anxiety, and social isolation. Although children with ASD have been the focus of most studies. In some of the studies, children have reported a high level of presence and engagement. They have also found the VR device and experience to be enjoyable, comfortable and easy to use. However, there is a word of caution that not all persons with ASD would find the HMDs tolerable. Hence, supervision during use is required, and general safety needs to be evaluated with more studies. Gaming addiction in children is also a pressing concern. However, as the authors point out, all conclusions cannot be generalised to the use of technology. Other factors come into play, such as low social competence, poor emotional regulation skills, and family issues. Games can promote collaboration, relaxation, and prosocial behaviours in children, which was needed during the COVID-19 pandemic social isolation period. To engage in social interactions in virtual communities, quick decisions need to be made regarding whom to

trust and avoid, and for effective group leadership. Regardless of these benefits, a balance in screentime exposure and gaming is recommended.

Related to ethical issues, Kaimara et al. (2022) conclude that screen time is what harms children's health and wellbeing the most, not VRT. The authors suggested a Family Media Plan tailored to each child, teenager, and family needs. Further, they stated that news agencies and parent magazines disseminate non-evidence-based information about the harms of technology use, thereby misinforming parents. To counter this misinformation, they called for more investigation to help concerned parents, teachers, and other stakeholders better understand the good and bad aspects of the technology for children.

2.8. Virtual Social Environments: 3D and 360° videos

Several studies have investigated the potential of manipulating virtual social environments for therapeutic purposes. Some of the studies, mostly with adults, used environments such as conference rooms with audiences, supermarkets, job interviews, restaurants, and cafes. In their study, Emmelkamp et al. (2020) reviewed the methods and essential components to consider when adopting virtual worlds for SAD treatment. Specifically, these components include virtual audiences, facial expressions, dialogue situations and verbal interactions between patients and virtual avatars. Results of the reviewed studies conclude that exposure to virtual social worlds and virtual humans led to high self-reported anxiety feelings, less eye gaze, and increased physiological arousal. Similarly, some studies found that both positive and negative dialogue feedback and audiences had considerable effects on participants. The authors conclude that more interactive virtual environments can enhance participants' perceived immersion.

Two technologies (or media) that provide immersive experiences of social situations are 3D and 360° videos. 3D virtual reality environments are immersive, computer-generated spaces that allow a user to move, manipulate, and actively engage with avatars using devices such as a joystick, offering autonomy and user choices within the virtual environment (Nason et al., 2020). 360° video is another technology which offers a fully immersive experience through a headset, but the user is more of a passive observer in a realistic, movie-like scenario without the ability to move and engage with the environment (Nason et al., 2020).

The effectiveness of 360° video and 3D virtual environments in the treatment of health-related conditions were compared in two studies. In Nason et al. (2020), grocery store 360° video and 3D virtual environments were exposed to 12 veteran soldiers with SAD

and PTSD symptoms as treatment and to examine their reactions. Participants in both environments reported being immersed, had minimal side effects of virtual environment exposure, and anxiety levels were moderate to strong. Powers et al. (2021) conducted a randomised controlled trial to investigate the efficacy of Computer-Generated Imagery (CGI) VR and Video Capture VR (360° video) of the same nature-themed scenes for pain reduction in inpatient participants (*n = 103*). Both VR conditions reduced pain by about 50% and improved relaxation, mood, and anxiety. Video capture VR was preferred over CGI due to its realistic features; however, the preference ratio was minimal.

While both VR and 360° environments have immersive effects, they differ in certain factors which should be considered based on the goal of the exposure treatment. These factors are described below:

Photorealism: Powers et al. (2021) stated that as the quality of computer-generated images in 3D VR improves, making them more lifelike, including the avatars, there is a high tendency for users to perceive the simulated world as unsettling, a term referred to as *uncanny valley effect*. Video Capture VR, on the other hand, is more realistic, eradicates CGI's eeriness similarity, and can record the minute details of the real-world environment, which is almost impossible with CGI.

Interaction and autonomy: With 360° videos, patients have limited engagement with feared objects (Stevens & Sherrill, 2021). Moreover, it is difficult for the user to "escape" from the situation as the environments are stitched static images moving at the pace of the video recording (Nason et al., 2020). In contrast, 3D VR environments allow for the user’s direct engagement with the environment, which may provide a greater sense of immersion (Nason et al., 2020). However, as Stevens and Sherrill (2021) note, there are cases where dynamic interaction is not essential for exposure therapy or where one-way interaction is sufficient, such as therapy for heights, crowded areas, or claustrophobic spaces

Anxiety-inducing effects: Nason et al. (2020) observed that while 3D VR computer-generated images are not entirely realistic like those of the real world, they can simulate environments that sufficiently evoke anxiety for treatment. Similarly, the absence of user interaction and control in 360° video environments may stimulate anxiety even more than in 3D VR.

Cost: Stevens and Sherrill (2021) describe that designing 360° videos is affordable, easy to set up and use, and can be shared easily on online video platforms. Although both 360° and 3D require some technical know-how, developing environments with 3D

computer graphics require substantial work hours, advanced technical expertise or purchase of VR software.

Environment Customisation: According to Stevens and Sherrill (2021), with 3D VR, it is relatively possible to create almost any environment, provided the availability of technical expertise and concept of the environment. In contrast, 360° video footage has to be taken in the real world in real situations, making 360° video less practical for some stimuli, for example, in war zones. Likewise, should the need arise to alter any part of the environment, such as time of day, weather, or specific location, more 360° videos that replicate the context are required. Yet another limitation is that the recorded video may not align with patients' viewpoints.

Ethics: Stevens and Sherrill (2021) also point out that many 360° videos are filmed in public spaces, and this recording may capture some people who find it uncomfortable to be in a third-party's video. Consequently, it introduces the need to seek prior permission. 360° videos directed at anxiety-related treatments may also be publicly available and may be used by treatment-seeking patients without clinical guidance. While these ethical concerns are non-existent in 3D VR, usage permission is still needed if the VR environment is not licensed under Creative Commons.

2.9. VRET for Social Anxiety Disorder and Related Mental Health Conditions

Adopted for therapy, the use of VR technology can reduce or eliminate many factors that could hinder the delivery of treatments to patients, such as time, cost, scalability, creation of traumatic scenarios or feared situations, and location. Studies have highlighted the efficacy of VR-delivered exposure treatments or assessments for different mental health-related conditions. For example, Ramsey et al. (2023) study on immersive VR Exposure (VRE) for the treatment of child anxiety disorders (e.g., spiders, storms, heights) provided evidence of VR exposure's feasibility and therapeutic benefits.

Likewise, the results of a combat-related PTSD study by Difede et al. (2022) of a clinical trial with VRE and prolonged imaginal exposure (PE) suggested VRE was more effective for depressed participants and PE for non-depressed participants. Primavera et al. (2024), in their study, found an improvement in the quality of life for individuals with bipolar disorder following a VR intervention called CEREBRUM. Similarly, a review and meta-analysis conducted by Romero-Ayuso et al. (2021) showed that VR-based interventions are more effective in improving sustained attention in children with attention deficit hyperactivity disorder (ADHD).

For persons with SAD, VRE can be conducted as therapist-led or self-guided but begins with the therapist directing the treatment process. In controlled trials, both modes of administration have been examined for their efficacy, with follow-ups lasting at least six months. The results of Zainal et al. (2021) using self-guided VRE (vs. wait list) with an inbuilt virtual therapist showed a greater reduction in SAD symptom severity, job interview fear, and trait worry from pre- to post-treatment. Equally, Rubin et al. (2022) clinician-administered randomised controlled trials of attention guidance of VRE for SAD using 360° video and eye tracking observed positive effects of their intervention on social anxiety symptoms.

In a systematic review of selected VR studies involving a total of 808 participants aged 18-65 years, Shahid et al. (2024) explored the evaluation and user experience of VR-based interventions for SAD in the context of safety, usability, acceptability, and attrition rates with adults. Their findings suggest that VRET can be a rapidly effective treatment for SAD with the potential to provide short- and long-term symptom improvement. Concerning user experience, low participant simulator sickness and absence of physical injuries were reported, supporting the notion that VR is considered a safe treatment for SAD. Usability levels were reported to be high in practitioner-delivered VR therapy to individual participants. Participants learned more about their anxiety and social situations based on their positive comments. Most of the reviewed studies reported that their participants completed the VR intervention and follow-up measurements, along with having low attrition within acceptable levels (< 20%).

Another systematic review and meta-analysis by Horigome et al. (2020), involving 22 adult population studies of 586 participants examined the efficacy of VR intervention for SAD, Public Speaking Anxiety (PSA), and FPS (Fear of Public Speaking). Their results showed that the efficacy of VR as exposure therapy for SAD had a larger effect and throughout the follow-up time points of 3 months to 6 years, long-lasting effect was recorded. However, there were no significant differences in attrition rates between VR intervention and in vivo exposure.

2.10. VRET Assessments and Treatment for Children and Adolescents

Research acknowledges VR's potential applications for youth. However, there is a lack of research on the efficacy of virtual reality exposure therapy (VRET) for anxiety disorders in children and adolescents (Kothgassner & Felnhofer, 2021). The systematic review by Kothgassner and Felnhofer (2021) yielded only 5 studies, which included 2 RCTs

(for school fears and spider phobia), 2 pre-post evaluations (for public speaking anxiety and fear of darkness) and 1 feasibility study (that of Parrish et al., 2016). While the reviewed studies conclude that VRET was able to reduce fears and is comparable to in vivo exposure, the authors noted the absence of VRET studies in the treatment of PTSD in young patients.

In the same way, the scoping review by Blanco et al. (2024) on the assessments and treatments of mental health conditions for children and adolescents leveraging virtual environments had just 13 studies, with only one targeted at social anxiety disorder. Additionally, based on Blanco et al. (2024) review, only the study of Parrish et al. (2016) focused on investigating the effects of VR social environments on participants' anxiety. Parrish et al. (2016) study included 41 adolescents with and without SAD exposed to party and public speaking virtual environments, as well as neutral virtual environments. Socially anxious youth had higher ratings of distress, with both groups experiencing acceptable levels of presence and immersion in the VR environments.

In an earlier study, Wong Sarver et al. (2014) investigated the feasibility and acceptability of VR environments for treating SAD in 11 children aged 8 to 12. The study utilised an interactive virtual school environment in a commercially available VR application developed by Virtually Better Inc. The children received Social Effectiveness Therapy for Children (SET-C), a behavioural treatment which combines group social skills training, peer generalisation, individual exposure therapy, and homework practice. The children, their clinicians, and their parents were all satisfied with the virtual treatment, indicating its potential utility in managing SAD and acquiring social skills in younger populations.

Wang et al. (2021) reviewed 33 studies involving the use of VR as an intervention for children with social skills deficits, a comorbid condition with SAD. Most of the reviewed studies reported the feasibility and acceptability of the intervention for children with social skills deficits. Particularly, they identified core social skills, such as social interaction, emotion recognition, empathy, and perspective-taking, which could be enhanced by VR intervention.

In summary, existing research on VRET for children and adolescents has demonstrated that exposure treatment is feasible, acceptable, and effective. However, there is limited research examining its application for young people with SAD. Additionally, fewer studies have assessed the effects of virtual social environments on participants' anxiety levels. More specifically, the use of a solely restaurant-based virtual environment has yet to be explored.

3. METHODOLOGY AND MATERIALS

This chapter delves into the materials and methods used for the study. Section 3.1 details the VR prototype development, focusing on the virtual environments' design, the tasks, and the application's mode of operation. Section 3.2 describes the design of the study, highlighting the experimental research method and variables. The demographics of the study's participants are given in Section 3.3. In Section 3.4, the descriptions of measures used in the study are provided. Section 3.5 provides an overview of the study procedure. Section 3.6 offers an overview of the data analysis approach.

3.1. VR Prototype Development

A desktop-based 3D virtual reality restaurant was developed to provide stimuli such as crowded spaces, noise, and social interactions that could be beneficial as a therapy supplement for addressing social anxiety in adolescents. The development of the application spanned 6 months, from the winter to the spring season.

3.1.1. The Virtual Environments

Two virtual environments were used in the prototype, one set in a restaurant and the other in a natural setting, built using the Unity game engine software (2022). Modifications to the prototype were made based on feedback from nurses at the Tays Adolescents Psychiatric Clinic after a series of demonstration sessions. The simulated restaurant environment was a readymade asset available from the Unity Asset store featuring a typical setting of a fast-food restaurant.

The VR restaurant environment, shown in Figure 1(p. 23) comprised three different exposure levels (Mild, Moderate, and Intense) with varied characteristics, such as sound, virtual characters, social interactions, and the scene setup being the same. The variation of the scene features was in increasing order of exposure level.

Figure 1. *Screenshots of the restaurant VR environment and introduction menu scene: (a) Mild scene. (b) Moderate scene. (c) Intense scene. (d) Intro scene*

The virtual characters in the VR environment were 3D models generated using Adobe Character Generator, Rigmodels, and Reallusion ActorCore online platforms. The characters in the scene were of varying age groups, race. The characters motions represented similar activities in a real-world fast-food restaurant, such as people chatting, placing orders, eating, and drinking. In order to make the characters as realistic as possible and interactive, the Salsa LipSync Suite plugin was used for mouth, eye gaze, and head movements. Eight of the characters, some of which are shown in Figure 2 (p. 24) had the roles of fast-food attendants and customers, could engage the player (i.e., the user) in a one-way verbal interaction based on the player's entry into a marked trigger area highlighted in the purple box in Figure 3 (p. 24). For the eight characters, their dialogues were as follows:

Attendants: Hello, please place your order using the self-service kiosk over there (pointing to the kiosk machine)

Customer 1: Would you like to sit with me? (beckoning with hand)

Customer 2: Hey! Watch where you are going!

Customer 3: Hi, I recommend this cheeseburger

Customer 4/5: The seat is free (this dialogue is initiated based on the selection of "Yes" button in a popup dialog)

Figure 2. *Collage screenshot of the virtual characters enabled for interaction: (a) One of the attendants. (b) Customer 1. (c) Customer 3. (d) Customer 2. (e) Teenagers*

Figure 3. *Marked trigger area in the restaurant VR environment*

The VR nature environment displayed in Figure 4 (p. 25) included sounds of birds, blowing wind and objects with which the user could interact. The purpose of the nature environment in the prototype was to ease the introduction and use of the VR environment and gadgets to the participants, particularly for those not familiar with the technology, as nature experiences have shown to have psychological and cognitive benefits (Bratman et al., 2012). The natural environment was used for practising actions and movements, such as grabbing or picking objects, selecting user interface (UI) elements, and teleporting. This served as preparation before exposure to the restaurant environment, the actual focus of the study.

Figure 4. *Screenshots of the VR nature environment*

3.1.2. Tasks in the VR Prototype

The VR application was designed to support carrying out a series of tasks, some of which include interactions with the virtual characters.

The main tasks include receiving instructions from the “Attendant” on where to place the food order, placing the order at the kiosk machine, picking up the order (food tray), and finding a table to sit at. Figure 5 shows the kiosk machine and food tray at the pickup station.

Figure 5. *Screenshot of the kiosk and food tray*

3.1.3. Operating the VR Prototype

The VR application prototype was tested with the Meta (formerly Oculus) Quest 2 and 3 headsets and was run on a gaming laptop with an NVIDIA GeForce GTX 3070 graphics card, an Intel Core i7-11800H CPU (3.60 GHz), and 32 GB of memory. To use the application, the Meta Quest headset needs to be connected to the computer running the VR prototype via a link cable with the Oculus Rift feature enabled on the headset. The Meta Quest controllers are used to move around in the VR environment and interact with

objects. The joystick on the controllers was configured for moving forward/backward/left/right and target areas, and the trigger buttons for selecting and grabbing objects. The first VR scene a user is presented with is the Main Menu, which provides brief details of all the other VR scenes, which are the exposure levels and the natural environment. A user can select and play a particular scene by clicking the checkbox next to the scene title and pressing the Start button.

3.2. Study Design

The study objectives were to investigate the feasibility of the developed VR prototype (independent variable). Specifically, it aimed to determine whether the application can induce any level of anxiety (dependent variable) and to evaluate the user experience. The selected research method was a within-subjects study, a subset of experimental research. MacKenzie (2013, p. 130) describes the method as one where each participant is exposed to all the experiment's conditions. The research method allows for generalisation of the research's results. It was also a suitable method to adopt due to the participant group, teenagers, being challenging to recruit. The experiment took place at the Tays clinic and in an enclosed room on the university campus. The language of instruction was mainly in English and partially in Finnish.

The independent variable had three levels: (1) Mild, (2) Moderate, and (3) Intense. These were the exposure levels in the VR prototype. For the study, different subjective dependent variables were measured with different tools related to distress feelings, virtual reality, and user experience. The measures are the Subjective Units of Distress Scale (SUDS; Wolpe, 1969), the Igroup Presence Questionnaire (IPQ; Igroup Project Consortium, n.d.), and the User Experience Questionnaire Plus (UEQ+; Schrepp & Thomaschewski, 2023). For VR, the variables included Experienced Realism, Involvement, Spatial Presence, General Presence, and Character Realism. The VR-related variables assessed participants' perception of the virtual restaurant environment. For user experience, the variables included Attractiveness, Efficiency, Stimulation, Usefulness, Visual Aesthetics, Intuitive Use, and Social Stimulation. The VR prototype was evaluated based on these seven user experience attributes. The last variable, "anxiety level", examined participants' feelings. More information on the measurement tools are provided in Section 3.4.

3.3. Participants

Eleven participants took part in the experiment, and the mean age was 15.8 years. Ten (male) were recruited through personal affiliations, and 1 (female) by the Tays nurse. Eight of the participants reported having experienced VR and used VR headsets at some point, and 3 had no prior VR experience. Of all the participants, only the one provided by the nurse was undergoing some form of disorder-related therapy at the Tays clinic; the others had no clinical diagnosis. Consent from parents was sought for participants below 15 years of age to participate in the study after explaining its purpose.

Participants' social anxiety levels were evaluated using the National Social Anxiety Centre (2016) format of the Liebowitz Social Anxiety Scale: For Children and Adolescents (see Appendix A, Figure 12). Seven participants reported having mild social anxiety, 1 reported moderate social anxiety, and 2 reported no social anxiety. A total of 10 participants completed the LSAS-CA assessment with a mean value of 39.40 (SD = 10.37).

There were no specific selection criteria for the experiment aside from participants being within the teenage age bracket. Although some participants wore eyeglasses, this did not pose any challenges for using the VR headset, as it could be adjusted for a comfortable fit.

3.4. Measures

Four self-assessment tools and one interview were administered in the current study: The LSAS-CA, the SUDS, the IPQ, the UEQ+, and a semi-structured interview. All measures included participant ID number for easy identification.

3.4.1. Liebowitz Social Anxiety Scale: For Children and Adolescents

The LSAS-CA questionnaire assessed respondents on 24 social situations related to fear and avoidance, commonly occurring in settings such as schools, grocery stores, restaurants, and public spaces. In the LSAS-CA, the fear category included four options with corresponding weighted values: None (0), Mild (1), Moderate (2), and Severe (3). Similarly, the avoidance category had four options with corresponding weighted values: Never (0), Occasionally (1), Often (2), and Usually (3). The overall score for each respondent determined their level of social anxiety, categorised as follows: 0-29 "You do not suffer from social anxiety", 30-49 "Mild social anxiety", 50-64 "Moderate social

anxiety", 65-79 "Marked social anxiety", 80-94 "Severe social anxiety", and 95 or higher "Very severe social anxiety".

A modified version of the LSAS-CA was created for the experiment to exclude the score after respondents submitted their responses. This was necessary to prevent unwanted reactions that could affect participants' emotions and the experiment's actualisation.

3.4.2. Subjective Units of Distress Scale

The Subjective Units of Distress Scale can be a useful way for individuals to express to their clinicians their experience of distress in anticipation of, during, or after a distressing situation or exposure exercise (Exposure Therapy Consortium, 2024). The SUDS (see Appendix A, Figure 13) used for the experiment was obtained online and modified to include emojis and a comment section to make it easier for participants to visually express and provide more context to their feelings. The subjective distress rating had a scale of 0 to 10, with corresponding labels.

3.4.3. Igroup Presence Questionnaire

The Igroup Presence Questionnaire measures the sense of presence experienced in a virtual environment through subjective ratings (Igroup Project Consortium, n.d.). The questionnaire comprises 14 items grouped into four scales: General Presence, Spatial Presence, Involvement, and Realism. Each item is rated on a 7-point scale with different response anchors and given a score from – 3 to +3. For the purpose of the study, the questionnaire was also slightly modified by the addition of the Character Realism scale, containing four questions to assess participants' perception of the virtual characters in the VR prototype. It should be pointed out that one of the questions in the Spatial Presence scale of the IPQ questionnaire was erroneously omitted. The Character Realism scale included the following questions:

1. How did the characters in the virtual world seem to you?
2. How did the characters' interaction(s) in the virtual world seem to you?
3. I felt like I was being spoken to by the characters in the virtual world
4. I felt like I was in the midst of people in the virtual world

3.4.4. User Experience Questionnaire Plus

The User Experience Questionnaire Plus is a modular extension of the User Experience Questionnaire, as stated by Schrepp and Thomaschewski (2023). It consists of both

pragmatic and hedonic qualities associated with the use of a product. Each scale in the questionnaire includes opposing pairs of product properties and is rated on a 7-point scale, with responses assigned a score from 1 to 7. Under each scale, there is the possibility for respondents to rate the importance of the respective scale for the evaluated product. The selected attributes for the user experience evaluation were chosen by the Tays clinic nurse and the researcher.

3.4.5. Semi-structured Interview

Information regarding participants' subjective perceptions of the user study and the VR prototype was gathered through a one-on-one interview conducted after the study session. The interview structure was an open-ended format and aimed to get feedback on their overall experience and obtain insights into the VR prototype's usability and areas for improvement. The interview had the following questions:

1. How was your overall experience with the session?
2. How was your experience with the VR world/system?
3. Did you experience any technical problems while using the application and/or equipment?
4. Would you be interested in using a similar system at some point in the future?
5. Is there something you would like to say about the prototype? e.g., ideas to improve it OR is there anything else you would like to mention?

3.5. Study Procedure

3.5.1. Before the experiment

On arrival at the experiment room, participants were allowed ample time to settle in before commencing the study procedures. Participants were then briefed on the experiment and their right to discontinue the study at any time if they wanted. The researcher also asked if the participants had any questions and answered them prior to signing the consent form. Thereafter, participants were asked to complete the LSAS-CA questionnaire. Explanations for some of the questions in the questionnaire were given where necessary.

3.5.2. Practice session in the VR prototype

Before commencing the actual experiment, participants were treated to a VR practice session. The session was conducted in the VR nature environment of the prototype.

Participants were invited to the experiment area and informed about the different exposure levels available in the application. The researcher gave the participants a brief explanation of how to wear the VR headset and use the hand controllers. They were then asked to start with the VR nature environment when ready for the practice. The purpose of practice has been described in section 3.1 of Chapter 3. In the VR nature environment, participants practised how to move around via teleportation and pick up objects. Once comfortable with the exercise, participants proceeded to the actual experimental tasks.

3.5.3. During the experimental tasks

The experimental tasks performed by the participants have been previously mentioned in Section 3.1 of Chapter 3. Participants had to test all three levels of exposure: mild, moderate, and intense. After each exposure session, participants took off the headset and completed the SUDS and IPQ measures to rate their experience in the VR restaurant prototype. For the SUDS, participants were asked to state reasons for their ratings in the comment section for each exposure level. During the experimental tasks, the researcher asked the participants about the comfortability of the headset to make adjustments where necessary. When participants encountered some issues while attempting the tasks, the researcher helped. Figure 6 shows some participants performing the experimental tasks.

Figure 6. *Pictures of some participants during the experiment*

3.5.4. After the experimental tasks

After all three tasks had been completed by the participants, they filled out the UEQ+ questionnaire (see Appendix A, Figures 14 and 15). An explanation of how to answer the questionnaire was provided. The Researcher's semi-structured interview session commenced thereafter. The researcher asked the participants 5 questions (see Appendix B, Figure 16) regarding their experience with the experiment setup, the VR prototype, challenges encountered, and suggestions for improvements. Also included in the discussion was if the participants experienced any simulator sickness. On average, a single session lasted about 1 hour 30 minutes.

3.6. Data Analysis

Quantitative and qualitative data were analysed with the statistical package IBM SPSS Statistics for Windows (version 28) and Excel. Due to the study's sample size (*n =11*), the data collected were not normally distributed. Thus, the Wilcoxon signed-rank test, a non-parametric test, was used. The effects of the VR prototype on anxiety levels and sense of presence were determined by post-host tests and pairwise comparisons. Additionally, correlations between social anxiety assessment and anxiety levels, and between exposure levels were determined using the Spearman's rank-order correlation coefficient, also a non-parametric measure. Significance levels (p-value) less than 0.05 in these tests are considered statistically significant and values above are deemed not significant. If values are significant, a pairwise comparison test was conducted to determine which of the exposure levels had more effects. Data collected from the interview were used to identify themes related to participants' experience of the user study, the prototype inclusive.

4. RESULTS

In this chapter, the results of the analysis of the data collected, both subjective and qualitative, are reported. In section 4.1, participants' subjective anxiety from the SUDS is presented. Section 4.2 explores the correlation between participants' baseline social anxiety, subjective distress, and exposure levels. The results of the VR and user experience assessments are described in sections 4.3 and 4.4. Qualitative data gathered from the semi-structured interview are discussed in section 4.5.

4.1. Subjective Anxiety

Figure 7 shows the results of the SUDS measuring the extent of changes in participants' anxiety across the exposure levels. The Friedman Test showed a statistically significant effect of the exposure levels on participants' anxiety levels, $\chi2(2) = 8.267$, $p < 0.05$. Post hoc pairwise comparison with Wilcoxon signed-ranked tests for the exposure levels showed that participants perceived the Intense level as having more anxiety-inducing effects than the Mild level, $\chi2(2) = -2.332$, $p = 0.020$. Other pairwise comparisons were not statistically significant. The average score and standard deviation (SD) for SUDS for the exposure levels were Mild 1.18 (0.982), Moderate 1.45 (1.128), and Intense 2.09 (1.136) respectively.

As shown in Table 1 (p. 33), of all the exposure levels, only the Intense level evoked *Minimal anxiety*, with a higher Mild-to-moderate anxiety recorded. *No anxiety or distress: Happy and fulfilled* occurred mostly in the Mild and Moderate levels.

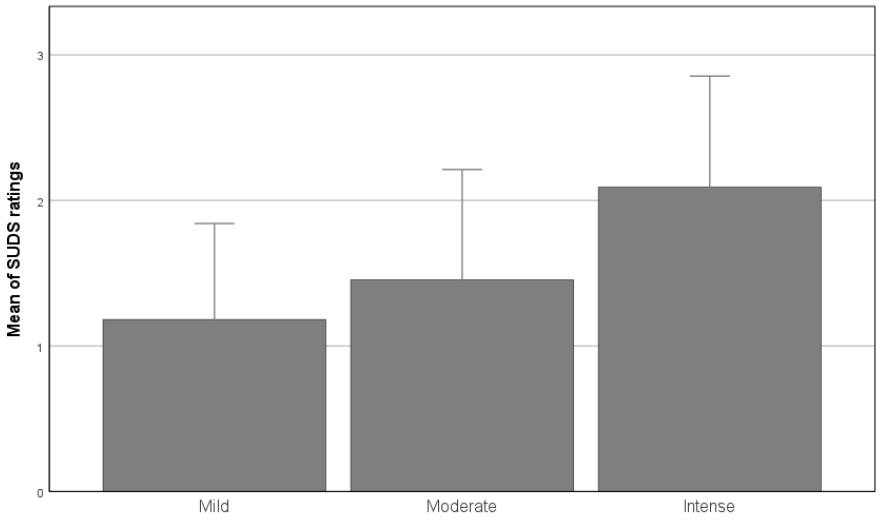

Figure 7. *Subjective assessment results of all participants' anxiety/distress after each exposure*

Table 1. *The frequency count of participants' anxiety level ratings per exposure level*

Anxiety Level	Mild	Moderate	Intense
No anxiety/distress: Happy and fulfilled	3	3	1
No anxiety/distress: Calm	4	2	2
No anxiety/distress: Neutral	3	4	4
Mild-to-moderate anxiety or distress	1	2	3
Minimal anxiety/distress	0	0	1

4.2. Association between Social Anxiety, Subjective Distress and Exposure Levels

Figure 8 shows the mean of subjective anxiety reported by participants across the exposure levels grouped by the different categories (labels) of social anxiety disorder based on the LSAS-CA assessment. Results of the Spearman's rank-order correlation presented in Table 2 (p. 34) show that there was a moderate positive relationship between the LSAS-CA scores and the Intense exposure level (r(8) = .631, p = .050), and was statistically significant. The LSAS-CA scores correlations with Mild (r(8) = .290, p = .416) and Moderate (r(8) = .235, p = .513) exposure levels were not statistically significant.

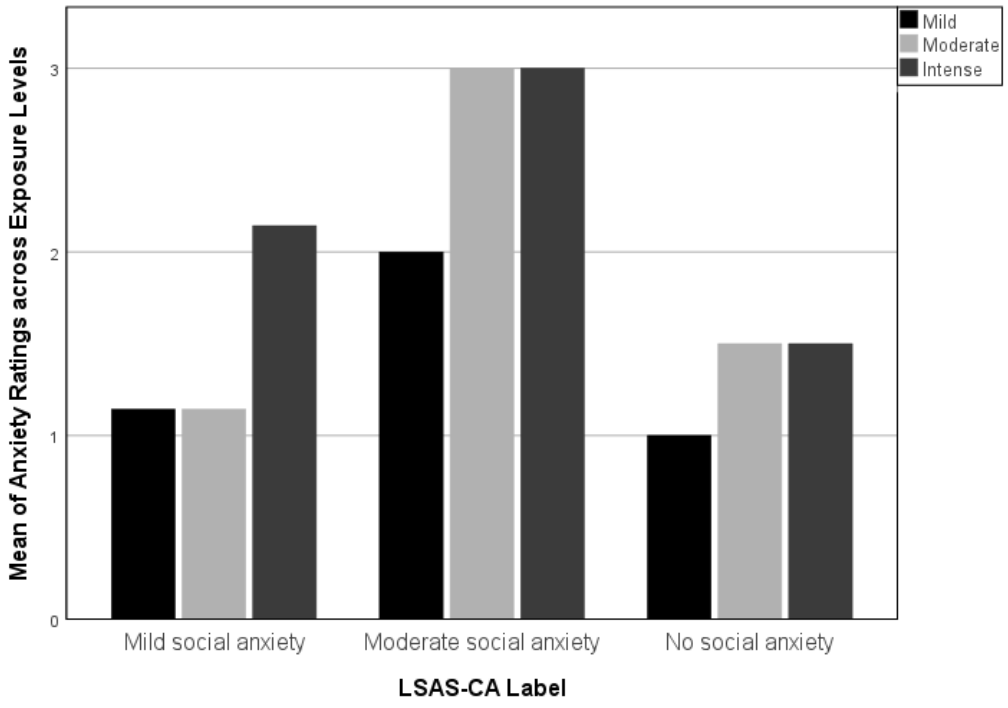

Figure 8. *Subjective anxiety across social anxiety (LSAS-CA) assessment*

Table 2. *Correlation analysis of LSAS-CA score and Subjective anxiety ratings per exposure level*

	LSAS-Score	**Mild**	**Moderate**	**Intense**
LSAS-Score r p-value	1 _	0.290 .416	0.235 .513	0.631 .050
Mild r p-value	0.290 .416	1 _	0.779 .008	0.628 .052
Moderate r p-value	0.235 .513	0.779 .008	1 _	0.659 .038
Intense r p-value	0.631 .050	0.628 .052	0.659 .038	1 _

To determine any correlations between the exposure levels in eliciting anxiety, Spearman's rank-order correlation was also conducted. The results indicate there are positive relationships and statistical significance between participants' anxiety ratings across the different exposure levels. Mild with Moderate ($r(9) = .771$, $p = .005$), Moderate with Intense ($r(9) = .648$, $p = .031$), and Mild with Intense ($r(9) = .644$, $p = .033$)

4.3. Sense of Presence in the VR Environment

In Figure 9 (p. 35), the results of the IPQ subjective evaluations are shown, measuring the sense of presence in the VR environment. A Friedman Test showed that there was no statistically significant influence of the exposure level participants were exposed to in relation to their sense of presence. The results are as follows: Involvement ($\chi2(2) = 1.556$, $p = 0.459$), Realism ($\chi2(2) = 1.429$, $p = 0.490$), Spatial Presence ($\chi2(2) = 0.974$, $p = 0.614$), General Presence ($\chi2(2) = 1.867$, $p = 0.393$), and Character Realism ($\chi2(2) = 0.927$, $p = 0.629$).

In terms of ratings, all three levels had positive and higher ratings on the General Presence scale. For the other scales, however, most of the ratings were negative, with Realism having the highest negative rating. The General Presence had mean scores of 0.55 (1.97), 1.00 (1.76), and 0.73 (1.66) for the mild, moderate, and intense levels respectively. Realism had mean scores of -0.14 (0.40), -0.36 (0.45), and -0.32 (0.33) across the exposure levels. For Spatial Presence, the mean scores included -0.23 (0.87), 0.07 (1.03), and -0.07 (1.09). The mean scores for Involvement were 0.09 (0.98), -0.09 (0.81), and -0.05 (0.86). Character Realism mean scores were 0.34 (0.62), 0.05 (0.72), and -0.09 (0.59).

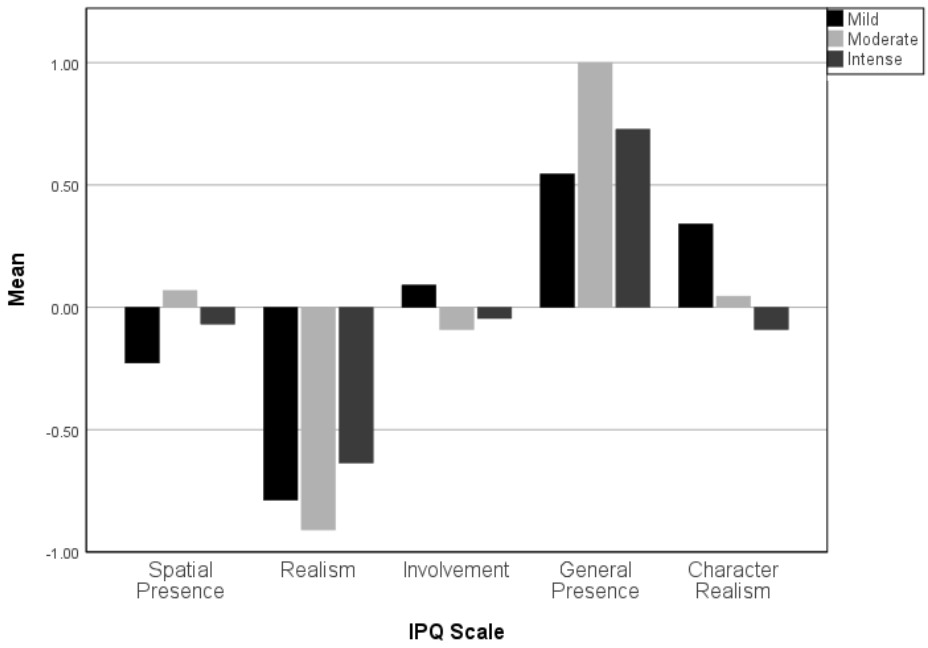

***Figure 9**. The overall sense of presence evaluation with the IPQ for all participants*

4.4. User Experience of the VR Prototype

The results of the UEQ+ evaluation of the prototype based on the seven attributes, Attractiveness, Efficiency, Stimulation, Usefulness, Visual Aesthetics, Intuitive Use, and Social Stimulation, described in section 3.2, are presented in Figure 10.

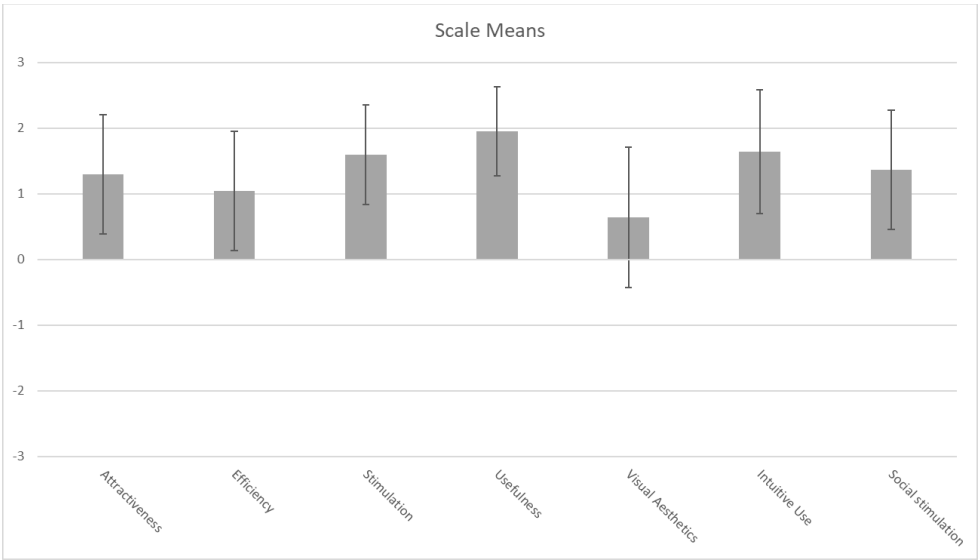

***Figure 10.** User Experience evaluation results of the seven selected attributes*

Participants rated the VR prototype positively on all scales, with the highest rankings on Usefulness, followed by Intuitive use, then Stimulation. In contrast, Visual aesthetics received the lowest rating. Attractiveness had a mean score of 1.30 (1.53), 1.05 (1.54) for Efficiency, 1.59 (1.28) for Stimulation, 1.95 (1.15) for Usefulness, 0.64 (1.81) for Visual Aesthetics, 1.64 (1.60) for Intuitive Use, and 1.36 (1.54) for Social Stimulation. Some

feedback from participants related to these attributes are discussed in the researcher's semi-structured interview responses in the next section.

Furthermore, the results of each item per selected scales provide individual identification for different aspects of the user experience. The mean scores per item are as follows: For the Attractiveness scale, the highest-rated item was "good" (1.64 [1.15]), while the lowest-rated item was on the "annoying/enjoyable" pair but still had a positive score (1.00 [1.86]). For the Efficiency scale, the highest rated item was "practical" (1.73 [0.86]), while the speed pair "slow/fast" had the lowest rating (0.36 [1.97]). The Usefulness scale had the highest rating across all items, with "useful" (2.36 [0.88]) and "helpful" (2.27 [0.86]) being the top-rated items. Likewise, the Stimulation scale generally had high ratings per item; the highest-rated item was "interesting" (1.91 [1.24]), followed by "exciting" (1.64 [1.30]). The Social Stimulation scale as well had high ratings across all items, with "socially encouraging" (1.55 [1.50]) and "socially inclusive" (1.45 [1.30]) having the highest ratings. Most of the items in the Visual Aesthetics scale had lower ratings, with the style pair "lacking style/stylish" having a neutral mean score (0.00 [1.65]), though it was considered "pleasant" (1.18 [1.53]). The Intuitive Use scale had high ratings for "conclusive" (2.00 [1.04]) and "plausible" (1.91 [0.79]), with lower ratings for the ease-of-use pair "difficulty/easy" (1.09 [2.07]).

In addition, 10 out of 11 participants completed the scale (attribute) importance part of the UEQ+. The results are shown in Figure 11.

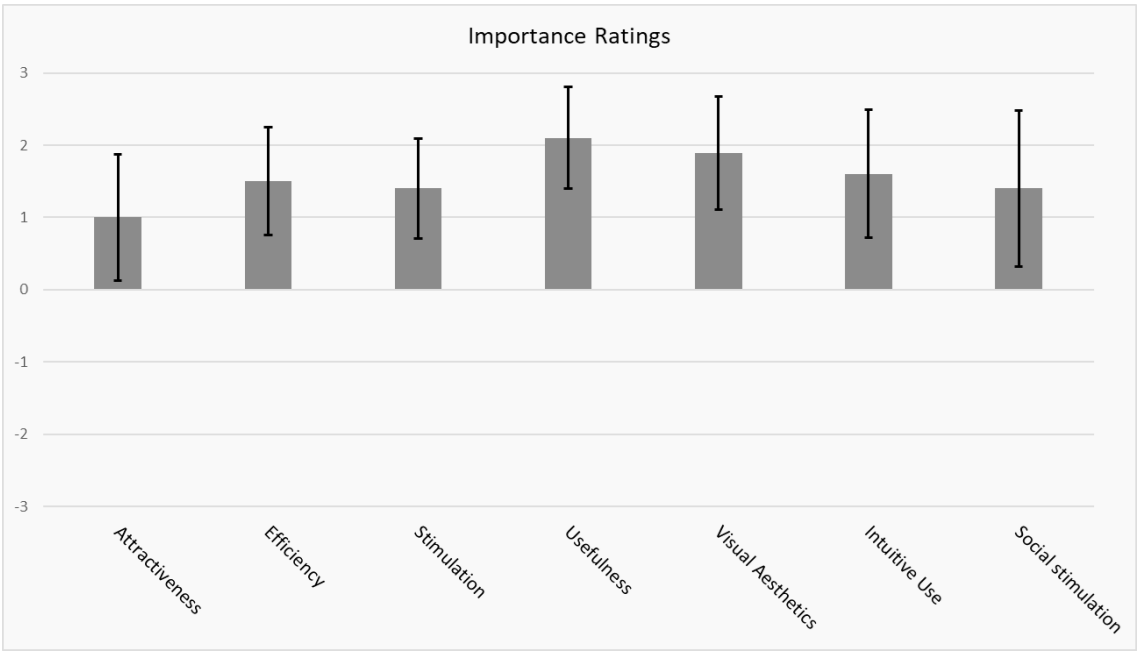

Figure 11. *Importance rating results of the 7 User Experience attributes*

After Usefulness, Visual aesthetics was ranked as the next most important attribute for the VR prototype, according to participants. The data importance ratings had a mean score of 1.00 (1.41) for Attractiveness, 1.50 (1.20) for Efficiency, 1.40 (1.11) for Stimulation, 2.10 (1.14) for Usefulness, 1.89 (1.20) for Visual Aesthetics, 1.60 (1.43) for Intuitive Use, and for Social Stimulation, the mean score was 1.40 (1.74).

4.5. Qualitative Results: Interviews

Ten participants provided context into their changes in anxiety levels at different exposure levels via the comment section in the SUDS. Six participants stated that their anxiety levels changed because of the virtual characters. For instance, P8 said, *"I was calm until the people started to stare at me and someone said, 'watch where you are going'...He was angry"*. P7 said, *"...when the people started staring at my eyes"*. Another change in anxiety levels occurred due to the increased population and sound. As reported by P6, *"I was at 3 when I saw there were so many people in the restaurant..."* and P11 said, *"...same as the last one, but it was a little too loud"*. However, two participants reported not having any changes in anxiety but commented on the realism of some of the exposure levels. For example, P9 mentioned that the intense level was *"basically the same [as the other levels], but this was way more realistic"*.

Additionally, after concluding all the test sessions, participants shared their opinions and feedback on the VR application prototype during the semi-structured interview with the researcher. The researcher took notes during the discussion and requested elaboration on comments where necessary.

The participants' experiences with the user study varied. Eight participants described their experiences positively, using words such as "calming", "nice", "good", and "incredible". Two participants highlighted gaining new experience, with one saying, *"It was kind of new"*, and another noting, *"It was pretty fun because I hadn't used a VR headset before"*. One participant felt the experience was neutral. None of the participants reported having simulator sickness, except one who mentioned that they experienced some dizziness due to the noise in the VR environment.

Regarding the VR system experience, 10 participants mentioned having positive experiences with the VR system. Two among them said, *"If I had more time with it, I could get lost in it"*, and *"When I took the glasses off, I felt I was in another world. You can get used to the VR system in 30 minutes"*. Another saying, *"It looks like a game..."*.

Conversely, participants expressed some negative feelings about the VR system for aspects such as less interaction with objects in the virtual environment, unnatural character speech, the emptiness of VR scene space, not knowing what buttons to press or use, and unrealistic food order waiting time. For example, P5 noted that the mild level *"was practically empty"*; P8 said, *"There are not too much specific things to do, like opening the food to eat"*; P9 expressed difficulty with the controller buttons stating they *"couldn't see them and didn't know what buttons to use"*. P11 commented on the virtual characters' gaze and speech, stating, *"It was weird that the characters all looked at me at the same time"* and *"The speech felt kind of robotic"*. They also said, *"The order time was unreal".*

All 11 participants expressed having some technical issues with the VR prototype. The most reported issue was the lag in the Intense level. Other issues were the delayed feedback when the controller buttons were pressed and the inability to recall the right buttons to use. The button issue was due to the lack of visible cues for the controllers in the VR prototype when participants had the VR headset on.

When asked about their interest in using a similar system in the future, 10 participants indicated willingness to try a similar system. P3 responded, *"Yes, if it helps"*. Likewise, P8 said, *"Yes, you can be more open and honest because you are alone, and you don't see the reaction of other person".* P7 was uncertain, citing concerns about possible addiction to the VR system, which would hinder successful social anxiety disorder treatments, particularly for youths.

The concluding question asked participants for more information about the prototype and generated some suggestions for improvement. Four participants suggested improving the virtual characters' facial features and user-virtual character (3D) interaction such that response can be given via dialogue inputs or through other interaction modalities. Two participants recommended making the characters' speech natural. As the USB cables attached to the HMD got in the way for some participants during the experiments, two participants proposed using a wireless or tethered HMD to increase the level of awareness and presence in the virtual environment. Two participants recommended increasing the waiting time for the food order, with one of them stating that payment for the order should also be included. Four participants mentioned increasing the background music, noise levels, and the number of people and introducing different landscapes outside the virtual restaurant environment to enhance immersion and realism for more anxiety-inducing experiences.

5. DISCUSSION

This chapter presents a discussion of the findings obtained from the VR prototype evaluation conducted. The chapter is divided into three sections. Firstly, in Section 5.1, the findings from the assessments of anxiety levels, VR and user experiences are presented. Secondly, Section 5.2 examines some implications the findings have for the design of VRET systems aimed at SAD. Finally, Section 5.3 reviews the limitations identified in the current study, serving as reflections for the author and considerations for future work.

5.1. Main Findings

For the thesis, a restaurant environment 3D VR prototype was developed to explore the feasibility of using VRET as a therapy supplement for teenagers with SAD receiving treatment at the Tays Adolescents Psychiatric Clinic. Additionally, the study sought to evaluate the user experience.

The study's findings demonstrated that the VR prototype was capable of causing minimal anxiety, highlighting the system's potential to create some degree of stimuli during exposure sessions. In the current study, there was a statistical significance of the effect of the exposure levels on participants' anxiety levels, with the Intense level having more inducing effects compared to the other two levels. Similarly, a relationship between the LSAS-CA social anxiety assessment and the Intense level was found to be positive and statistically significant. These findings suggest that the intense level could be used as a baseline for structuring the exposure hierarchy to elicit anxiety responses. The stimuli within the intense level environment appeared to trigger anxiety in socially anxious participants. The strong and positive relationships between the exposure levels further suggest that most participants had increasing levels of anxiety as they progressed through the exposures. Taken together, these findings align with those of Parrish et al. (2016) in which socially anxious youths had reported higher anxiety ratings, although the virtual environments are different.

As reported by participants in the SUDS assessment, a mild-to-moderate distress feeling was apparent in the Intense level with a frequency count of 3 and 1 count of minimal distress. Participants' anxiety levels were mainly neutral and calm in the mild and moderate levels. Qualitative results from participants provided more insights into the findings. Some of the factors that contributed to changes in anxiety levels were the virtual characters' appearance and personality, interaction capabilities, and sound in the

environment, as noted by participants. For an objective assessment of anxiety level changes, the use of sensors could be helpful for tracking physiological responses, such as heart rate, along with self-report measures, as suggested by Ferreira et al. (2022).

In the current study, the results of the sense of presence evaluation of the VR restaurant application across the three exposure levels showed that General Presence had the highest positive ratings, while Realism received the highest negative ratings. This presents an interesting contrast between how participants perceived the overall sense of presence and the specific aspect of realism within the virtual environment.

Some assumptions can be made from this phenomenon. Firstly, higher ratings of General Presence suggest participants still felt a sense of “being there” in the virtual environment, even if it did not closely match reality. Similarly, the negative ratings of Realism did not significantly affect the overall feeling of presence. Secondly, there is a possibility that the VR prototype was engaging on an emotional or cognitive level, which could have led to an increase in participants’ sense of presence even with less perfection in realism. As mentioned by some of the participants in section 4.5, the VR exposure study was their first VR experience. Lastly, it also suggests that a high-quality realism for the VR prototype’s scenes, i.e., in replicating the real world, is not a major determinant for achieving a strong sense of presence, although it may contribute to it. This concurs with the study by Jung and Lindeman (2021) that suggests *Preference* as a new evaluation metric for VR experiences. Participants might have considered other aspects of the VR experience, such as audio, interactions, field of view, environment design, or tasks in the VR, as engaging enough.

Another interesting finding is the variation in the IPQ scale mean scores across the three exposure levels. While Involvement and Spatial Presence were almost similar in ratings, Realism, including Character Realism, declined as intensity increased. As previously mentioned of the omission of one question in the Spatial Presence scale in the measures sub-section in Chapter 3, the ratings of the scale may have been different. Nonetheless, the result suggests that as participants became aware that the VR environment was the same for all exposure levels, their expectations changed, leading to a decrease in how they perceived the environment. The influence of the environment’s familiarity was recognised as a limitation, which is further discussed in section 5.3.

The virtual characters used in the study were realistic 3D models with close-to-natural expressions and animations. The personalities of some of the characters were grumpy and cheerful, and others were neutral. Some participants stated that they felt

uncomfortable with the gaze of some of these characters. A few of them said the speech of some characters affected their feelings. Yet, other participants expressed that they were not affected by the appearance of the virtual characters. Another aspect was the interaction possibilities in the VR environment. A few of the participants expressed their desire to interact more with objects in the prototype. These findings are in line with the study outcomes of Emmelkamp et al. (2020) on the effects of virtual characters and dialogue on participants in the reviewed studies, including having more interactive virtual environments.

Regarding user experience, participants found the VR prototype to be useful, stimulating, and intuitive to use. The social aspects were also considered to be positive. This result suggests that participants deemed the prototype to be of relevance, evocative, aligning with mental models in terms of use, and encourages socialisation. However, they noted significant shortcomings in visual aesthetics and efficiency, specifically in terms of style and speed. The main issues included the emptiness of the exterior design of the restaurant VR environment and technical difficulties experienced, such as delayed response to button presses on the controllers, and some glitches observed when moving within the environment. These delays, combined with less visual appeal, led to lower ratings. Given that youngsters are accustomed to fast, responsive interactions in games, their expectations for similar performance in the VR prototype were not met. The results and observations indicate the need for enhancements in the design aspects and performance of the system to improve the overall user experience.

5.2. Implications for VRET Application Design

The study results contribute to research into the use of VR for mental health for children and adolescents. Although minimal, the VR prototype developed induced some level of distress, supporting the use of VR technology for exposure therapy. Care should still be taken in the use of the technology due to identified post-use effects such as dizziness and eye fatigue.

Based on participants' views, it was clear that to elicit the anxiety-inducing effects required for VRET, high-quality visual aesthetics, spatial audio, interaction capabilities, and performance are crucial and should be prioritised. Naturalistic sounds, which could be recorded by human voices with realistic visuals, including the ability to interact with virtual characters and objects in the VR environment, have a significant impact on users' experience, enhancing the realism, engagement, and effectiveness of exposure treatment. Some participants expressed their desire to interact with the virtual characters in different

ways, such as through speech and text input dialogues. This suggests a need for multimodal interaction and consideration of user preferences in such systems to further enhance the user experience.

For the treatment of social anxiety disorder using VRET, the exposure hierarchy or level should be designed with varied scenes and tasks that gradually increase in complexity and social interaction, thereby reducing the learning effects from previous exposure levels. This was demonstrated in the study by Kim et al. (2017) involving an adult SAD participant exposed to different social situations in a self-training therapy and that of Ramsey et al. (2023). For example, a restaurant-themed environment for exposure treatment therapy could progress from a small, low-traffic restaurant to a moderately busy one and finally to a large, crowded restaurant. Each setting would feature virtual characters displaying different personalities and behaviours, gradually increasing the intensity of social interaction.

In VR systems intended for medical interventions, especially for young users, and where task performance is needed, a practice virtual environment should be included as part of its features. Integrating a natural environment is recommended to ease and relax participants and carry out practice of using the technology. This can be particularly beneficial for those with no prior VR experience, providing a less frightening introduction before progressing to challenging scenarios.

5.3. Limitations

A number of limitations were observed in the study, which should be acknowledged and considered when interpreting the results. First, the initial plan for the study was to evaluate the prototype with teenagers with marked social anxiety whom the nurses at the Tays clinic are working with. As this was not feasible, the study was conducted with participants not undergoing any SAD-related therapy. The LSAS-CA was used to determine whether individuals participating in the study had social anxiety. This was merely to understand if the anxiety influenced their responses and to have somewhat a representative characteristic similar to the main target group. The results of the study might have yielded different results if it had been conducted with clinically diagnosed SAD individuals. Nevertheless, this could require strict research protocols that could possibly affect the thesis timeline. Second, the study included participants from diverse nationalities and cultures residing in Finland, but there was a significant gender imbalance, with only one female participant. This raises the question of whether gender might influence anxiety levels with the developed prototype, a factor that remains unexplored.

Next, both learning and sequence effects (MacKenzie, 2013, p. 177) were observed in the study. The three exposure levels of the VR prototype had the same features, and they were evaluated one after the other. Participants were also given the same tasks for each level. Noticeably, participants completed the experimental tasks rather quickly compared to the first level, where they had to learn how to do the task. Additionally, task performance degraded over the last two levels as participants skipped some steps in the tasks once they realised the tasks could still be completed.

Additional limitations were noted in the naming convention of the exposure levels. Participants were informed about and shown the names of the levels at the beginning of the experiment, which may have biased their perception and self-assessment of anxiety levels post-exposure. However, this assumption remains inconclusive, as only the mild-to-moderate anxiety ratings showed an increasing trend across the levels based on frequency counts, while other ratings did not follow a normal distribution.

A fifth limitation was found in the self-assessment questionnaires administered. Some participants noted that certain questions in the IPQ measure felt similar, and for the UEQ+, they encountered new words being non-native English speakers. Although efforts were made to explain the unclear areas using simple analogies, and the questionnaire instructions advised the young participants not to overthink their responses, it cannot be determined whether participants fully grasped the explanations. Moreover, despite being encouraged to ask for clarification, many participants did not do so, making it difficult to assess their understanding of the questions.

The VR prototype was developed by the author who had limited technical expertise in VR development, which resulted in shortcomings in visual design, interaction capabilities, and overall performance. These shortcomings were pointed out by participants and were already recognised before the experiments commenced but there was constrained capacity to make significant improvements.

Finally, the involvement of the Tays Adolescents Psychiatric clinic nurses was limited in this study. The nurses primarily participated during the development and prototyping phases. Only one experiment session, which included a participant recruited by the clinic's contact person, involved a nurse and a health practitioner who assisted with language translation and explanation. Although this session included a UEQ+ assessment for the nurse, it was excluded from the data analysis due to insufficient data. Given that the VR prototype was designed for exposure therapy administered by therapist nurses,

gaining their insights and evaluations could have been valuable. However, the therapist's administration setup of the VR prototype was beyond the scope of this study.

6. CONCLUSION

A restaurant-themed 3D VR application prototype with three exposure levels, Mild, Moderate, and Intense, was developed and evaluated in this thesis. The evaluation focused on determining the extent to which the prototype could induce anxiety during exposure. The exposure levels had differing effects on participants' subjective anxiety levels. The Intense level had a more significant effect, evoking minimal anxiety, while the other levels had less impact. Similarly, there was a relationship between social anxiety assessments and post-exposure subjective anxiety ratings.

The sense of presence in the VR prototype and the overall user experience were also studied in the thesis. For the VR experience, the study found no significant influence of the sense of presence in the VR application on participants' anxiety levels. Realism was the lowest in the VR experience, while General Presence ranked highest. Notwithstanding, the VR system effectively created a perception of "being somewhere else", even with less realness to the real world. The user experience evaluation revealed that while the VR prototype was perceived as useful, stimulating, and intuitive, it was less visually appealing to participants. Visual aesthetics was ranked the second most important attribute needed for the prototype after Usefulness.

The study supports existing research on the benefits of VRET for treating social anxiety disorder. It also emphasises the importance of key design elements such as visual appeal, realism, and interaction capabilities, particularly for the exposure treatment hierarchy, which should be prioritised when designing VRET systems for the target user groups. The study's outcome, the VR prototype inducing minimal anxiety during exposure and the mostly positive user experience evaluations, addressed the research question and fulfilled the study's objectives. To the best of the author's knowledge, this study appears to be the first to specifically explore a solely restaurant-based virtual environment setting for exposure therapy aimed at adolescents with social anxiety. It is important to reiterate, however, that the study participants were not clinically diagnosed with SAD.

VRET as a therapy supplement has promising prospects to empower therapists by providing personalised treatments suited to the specific needs of their patients, enhancing the effectiveness of care and reducing dropout rates. Future research could explore the development and evaluation of better-implemented VRET applications with higher degrees of stimuli and multimodal interaction techniques for user-virtual character interaction in the VR environment.

REFERENCES

Acquah, E. O., Topalli, P. Z., Wilson, M. L., Junttila, N., & Niemi, P. M. (2016). Adolescent loneliness and social anxiety as predictors of bullying victimisation. International *Journal of Adolescence and Youth, 21*(3), 320-331.

Aderka, I. M., Hofmann, S. G., Nickerson, A., Hermesh, H., Gilboa-Schechtman, E., & Marom, S. (2012). Functional impairment in social anxiety disorder. *Journal of anxiety disorders,* 26(3), 393-400.

Alsamghan, A. S. (2020). Social Anxiety Symptoms and Quality of Life of Secondary School Students of Abha, Saudi Arabia. *The Journal of Genetic Psychology, 182*(1), 18–30. https://doi.org/10.1080/00221325.2020.1837065

American Psychiatric Association, D. S. M. T. F., & American Psychiatric Association, D. S. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (Vol. 5, No. 5). Washington, DC: American psychiatric association.

American Psychological Association. (2017). *What is Exposure Therapy?* https://www.apa.org/ptsd-guideline/patients-and-families/exposure-therapy Accessed on 26.08.2024

Bandelow, B., Michaelis, S., & Wedekind, D. (2017). Treatment of anxiety disorders. *Dialogues in Clinical Neuroscience, 19*(2), 93–107. https://doi.org/10.31887/DCNS.2017.19.2/bbandelow

Blanco, C., Bragdon, L. B., Schneier, F. R., & Liebowitz, M. R. (2013). The evidence-based pharmacotherapy of social anxiety disorder. *International Journal of Neuropsychopharmacology*, *16*(1), 235-249. https://doi.org/10.1017/S1461145712000119

Blanco, C., Bragdon, L., Schneier, F. R., & Liebowitz, M. R. (2014). Chapter 22 - Psychopharmacology for Social Anxiety Disorder. In *Social Anxiety* (Third Edition, pp. 625–659). Elsevier Inc. https://doi.org/10.1016/B978-0-12-394427-6.00022-4

Blanco, D., Roberts, R. M., Gannoni, A., & Cook, S. (2024). Assessment and treatment of mental health conditions in children and adolescents: A systematic scoping review of how virtual reality environments have been used. *Clinical Child Psychology and Psychiatry, 29*(3), 1070–1086. https://doi.org/10.1177/13591045231204082

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences, 1249*(1), 118–136. https://doi.org/10.1111/j.1749-6632.2011.06400.x

Creswell, C., Waite, P., & Cooper, P. J. (2014). Assessment and management of anxiety disorders in children and adolescents. *Archives of Disease in Childhood*, *99*(7), 674–678. https://doi.org/10.1136/archdischild-2013-303768

Crozier, M., Gillihan, S. J., & Powers, M. B. (2011). Issues in Differential Diagnosis: Phobias and Phobic Conditions. In *Handbook of Child and Adolescent Anxiety Disorders* (pp. 7–22). Springer New York. https://doi.org/10.1007/978-1-4419-7784-7_2

de Jong, R., Lommen, M. J., van Hout, W. J., de Jong, P. J., & Nauta, M. H. (2020). Therapists' characteristics associated with the (non-) use of exposure in the treatment of anxiety disorders in youth: A survey among Dutch-speaking mental health practitioners. *Journal of Anxiety Disorders, 73*, 102230.

de Ponti, N., Matbouriahi, M., Franco, P., Harrer, M., Miguel, C., Papola, D., Sicimoğlu, A., Cuijpers, P., & Karyotaki, E. (2024). The efficacy of psychotherapy for social anxiety disorder, a systematic review and meta-analysis. *Journal of anxiety disorders, 104*, 102881. https://doi.org/10.1016/j.janxdis.2024.102881

Difede, J., Rothbaum, B. O., Rizzo, A. A., Wyka, K., Spielman, L., Reist, C., Roy, M. J., Jovanovic, T., Norrholm, S. D., Cukor, J., Olden, M., Glatt, C. E., & Lee, F. S. (2022). Enhancing exposure therapy for posttraumatic stress disorder (PTSD): a randomized clinical trial of virtual reality and imaginal exposure with a cognitive enhancer. *Translational Psychiatry, 12*(1), 299–9. https://doi.org/10.1038/s41398-022-02066-x

Emmelkamp, P. M. G., Meyerbröker, K., & Morina, N. (2020). Virtual Reality Therapy in Social Anxiety Disorder. *Current Psychiatry Reports, 22*(7), 32–32. https://doi.org/10.1007/s11920-020-01156-1

Exposure Therapy Consortium. (2024, July 22). *Connecting with experts: Exposure therapy consortium membership benefits*. https://www.exposuretherapyinfo.org/post/connecting-with-experts-exposure-therapy-consortium-membership-benefits Accessed on 15.09.2024

Ferreira, J., Ferreira-Brito, F., Guerreiro, J., & Guerreiro, T. J. (2022). Using VR and Sensors for Anxiety with Children and Adolescents. In *VR4Health@ MUM* (pp. 14-18).

Freidl, E. K., Stroeh, O. M., Elkins, R. M., Steinberg, E., Albano, A. M., & Rynn, M. (2017). Assessment and Treatment of Anxiety Among Children and Adolescents. *Focus, 15*(2), 144–156. https://doi.org/10.1176/appi.focus.20160047

Herbert, J. D., Brandsma, L. L., & Fischer, L. (2014). Chapter 3 - Assessment of Social Anxiety and its Clinical Expressions. In *Social Anxiety* (Third Edition, pp. 45–94). Elsevier Inc. https://doi.org/10.1016/B978-0-12-394427-6.00003-0

Horigome, T., Kurokawa, S., Sawada, K., Kudo, S., Shiga, K., Mimura, M., & Kishimoto, T. (2020). Virtual reality exposure therapy for social anxiety disorder: a systematic review and meta-analysis. *Psychological Medicine, 50*(15), 2487–2497. https://doi.org/10.1017/S0033291720003785

Igroup Project Consortium. (n.d.). *Igroup Presence Questionnaire (IPQ) Overview*. http://www.igroup.org/pq/ipq/index.php Accessed on 15.09.2024

Jung, S., & Lindeman, Robert. W. (2021). Perspective: Does Realism Improve Presence in VR? Suggesting a Model and Metric for VR Experience Evaluation. *Frontiers in Virtual Reality, 2*. https://doi.org/10.3389/frvir.2021.693327.

Kaczkurkin, A. N., & Foa, E. B. (2015). Cognitive-behavioural therapy for anxiety disorders: an update on the empirical evidence. *Dialogues in Clinical Neuroscience, 17*(3), 337–346. https://doi.org/10.31887/DCNS.2015.17.3/akaczkurkin

Kaimara, P., Oikonomou, A., & Deliyannis, I. (2022). Could virtual reality applications pose real risks to children and adolescents? A systematic review of ethical issues and concerns. Virtual Reality: *The Journal of the Virtual Reality Society, 26*(2), 697–735. https://doi.org/10.1007/s10055-021-00563-w

Khan, A. N., Bilek, E., Tomlinson, R. C., & Becker-Haimes, E. M. (2021). Treating Social Anxiety in an Era of Social Distancing: Adapting Exposure Therapy for Youth During COVID-19. *Cognitive and Behavioural Practice, 28*(4), 669–678. https://doi.org/10.1016/j.cbpra.2020.12.002

Kim, H. E., Hong, Y. J., Kim, M. K., Jung, Y. H., Kyeong, S., & Kim, J. J. (2017). Effectiveness of self-training using the mobile-based virtual reality program in patients with social anxiety disorder. *Computers in Human Behaviour, 73*, 614-619.

Kothgassner, O. D., & Felnhofer, A. (2021). Lack of research on efficacy of virtual reality exposure therapy (VRET) for anxiety disorders in children and adolescents: A systematic review. *Neuropsychiatrie, 35*(2), 68–75. https://doi.org/10.1007/s40211-020-00349-7

Koyuncu, A., İnce, E., Ertekin, E., & Tükel, R. (2019). Comorbidity in social anxiety disorder: diagnostic and therapeutic challenges. *Drugs in context*, 8, 212573. https://doi-org.libproxy.tuni.fi/10.7573/dic.212573

Levy, A. N., Nittas, V., & Wray, T. B. (2023). Patient Perceptions of In Vivo Versus Virtual Reality Exposures for the Treatment of Anxiety Disorders: Cross-Sectional Survey Study. *JMIR Formative Research, 7*, e47443–e47443. https://doi.org/10.2196/47443

MacKenzie, I. S. (2012). *Human-Computer Interaction: An Empirical Research Perspective* (1st ed.). Elsevier Science. https://doi.org/10.1016/C2012-0-02819-0

Maples-Keller, J. L., Bunnell, B. E., Kim, S.J., & Rothbaum, B. O. (2017). The Use of Virtual Reality Technology in the Treatment of Anxiety and Other Psychiatric Disorders. *Harvard Review of Psychiatry, 25*(3), 103–113. https://doi.org/10.1097/hrp.0000000000000138

Marmorstein, N. R., White, H. R., Loeber, R., & Stouthamer-Loeber, M. (2010). Anxiety as a Predictor of Age at First Use of Substances and Progression to Substance

Use Problems Among Boys. *Journal of Abnormal Child Psychology, 38*(2), 211–224. https://doi.org/10.1007/s10802-009-9360-y

Masia, C. L., Klein, R. G., Storch, E. A., & Corda, B. (2001). School-Based Behavioural Treatment for Social Anxiety Disorder in Adolescents: Results of a Pilot Study. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(7), 780–786. https://doi.org/10.1097/00004583-200107000-00012

Meta (2020) *Meta avatars*. https://www.meta.com/fi/en/avatars/ Accessed on 25.03.2024

Nason, E. E., Trahan, M., Smith, S., Metsis, V., & Selber, K. (2020). Virtual treatment for veteran social anxiety disorder: A comparison of 360° video and 3D virtual reality. *Journal of Technology in Human Services, 38*(3), 288–308. https://doi.org/10.1080/15228835.2019.1692760

National Social Anxiety Centre (NSAC, 2016). *Liebowitz Social Anxiety Scale: For Children & Adolescents (LSAS-CA)* https://nationalsocialanxietycenter.com/self-scoring-questionnaire-children/ Accessed on 24.06.2024

Otto, M. W., Smits, J. A. J., & Reese, H. E. (2004). Cognitive-behavioural therapy for the treatment of anxiety disorders. *The Journal of Clinical Psychiatry, 65*(5), 34–41.

Parrish, D. E., Oxhandler, H. K., Duron, J. F., Swank, P., & Bordnick, P. (2016). Feasibility of Virtual Reality Environments for Adolescent Social Anxiety Disorder. *Research on Social Work Practice*, 26(7), 825-835. https://doi.org/10.1177/1049731514568897

Pittig, A., Kotter, R., & Hoyer, J. (2019). The struggle of behavioural therapists with exposure: self-reported practicability, negative beliefs, and therapist distress about exposure-based interventions. *Behaviour Therapy, 50*(2), 353-366.

Powers, M. B., Carl, E., Levihn-Coon, A., Van Veldhuizen, M., Caven, A., Pogue, J., Fresnedo, M., Turner, E. D., Adams, M., Leonard, K., Conroy, H., Lantrip, C., Caven, T., Isbell, C., Regner, J., Garmon, E., Foreman, M., Miller, W., Fares, L. A., … Smits, J. A. J. (2021). Nonpharmacologic Pain Management Among Hospitalized Inpatients: A Randomized Waitlist-Controlled Trial of Standard Virtual Reality (CGI VR) Versus Video Capture VR (360 degrees 3D/Stereoscopic Video Capture VR). *The Clinical Journal of Pain, 37*(9), 678–687. https://doi.org/10.1097/AJP.0000000000000958

Powers, M. B., Kauffman, B. Y., Diamond, A., & Smits, J. A. J. (2014). Chapter 26 - A Comparison between Psychosocial and Pharmacological Treatments. In *Social Anxiety* (Third Edition, pp. 753–775). Elsevier Inc. https://doi.org/10.1016/B978-0-12-394427-6.00026-1

Primavera, D., Migliaccio, G. M., Garau, V., Orrù, G., Scano, A., Perra, A., & Sancassiani, F. (2024). Improving Quality of Life in Bipolar Disorders with an Immersive

Virtual Reality Remediation Training Randomized Controlled Trial (RCT). *Journal of Clinical Medicine, 13*(13), 3886.

Ramsey, K. A., Essoe, J. K.-Y., Boyle, N., Patrick, A. K., & McGuire, J. F. (2023). Immersive Virtual Reality Exposures for the Treatment of Childhood Anxiety. *Child Psychiatry and Human Development*. https://doi.org/10.1007/s10578-023-01628-4

Ranta, K., Aalto-Setälä, T., Heikkinen, T., & Kiviruusu, O. (2024). Social anxiety in Finnish adolescents from 2013 to 2021: Change from pre-COVID-19 to COVID-19 era, and mid-pandemic correlates. *Social psychiatry and psychiatric epidemiology*, 59(1), 121-136. https://doi.org/10.1007/s00127-023-02466-4

Reeves, R., Curran, D., Gleeson, A., & Hanna, D. (2022). A Meta-Analysis of the Efficacy of Virtual Reality and In Vivo Exposure Therapy as Psychological Interventions for Public Speaking Anxiety. *Behavior Modification, 46*(4), 937-965. https://doi.org/10.1177/0145445521991102

Riva G. (2022). Virtual Reality in Clinical Psychology. *Comprehensive Clinical Psychology*, 91–105. https://doi.org/10.1016/B978-0-12-818697-8.00006-6

Riva, G., & Serino, S. (2021). *Virtual Reality in the Assessment, Understanding and Treatment of Mental Health Disorders*. MDPI - Multidisciplinary Digital Publishing Institute.

Riva, G., Botella, C., Baños, R., Mantovani, F., García-Palacios, A., Quero, S., Serino, S., Triberti, S., Repetto, C., Dakanalis, A., Villani, D., & Gaggioli, A. (2015). Presence-Inducing Media for Mental Health Applications. In *Immersed in Media* (pp. 283–332). Springer International Publishing. https://doi.org/10.1007/978-3-319-10190-3_12

Romero-Ayuso, D., Toledano-González, A., Rodríguez-Martínez, M. D. C., Arroyo-Castillo, P., Triviño-Juárez, J. M., González, P., Ariza-Vega, P., González, A. D. P., & Segura-Fragoso, A. (2021). Effectiveness of Virtual Reality-Based Interventions for Children and Adolescents with ADHD: A Systematic Review and Meta-Analysis. *Children (Basel)*, 8(2), 70-. https://doi.org/10.3390/children8020070

Rowa, K., Milosevic, I., & Antony, M. M. (2014). Cognitive-Behavioral Therapy for Social Anxiety Disorder: Applying the Approach. In *The Wiley Blackwell Handbook of Social Anxiety Disorder* (pp. 498–520). John Wiley & Sons, Incorporated. https://doi.org/10.1002/9781118653920.ch23

Rubin, M., Muller, K., Hayhoe, M. M., & Telch, M. J. (2022). Attention guidance augmentation of virtual reality exposure therapy for social anxiety disorder: a pilot randomized controlled trial. *Cognitive Behaviour Therapy, 51*(5), 371–387. https://doi-org.libproxy.tuni.fi/10.1080/16506073.2022.2053882

Salari, N., Heidarian, P., Hassanabadi, M., Babajani, F., Abdoli, N., Aminian, M., & Mohammadi, M. (2024). Global Prevalence of Social Anxiety Disorder in Children, Adolescents and Youth: A Systematic Review and Meta-analysis. *Journal of Prevention*, 1-19. https://doi.org/10.1007/s10935-024-00789-9

Scheveneels, S., De Witte, N., & Van Daele, T. (2023). The first steps in facing your fears: The acceptability of virtual reality and in vivo exposure treatment for specific fears. *Journal of anxiety disorders, 95*, 102695.

Schrepp, M., & Thomaschewski, J. (2023). Handbook for the modular extension of the User Experience Questionnaire (Version 6). In *Mensch & Computer* (pp. 1-19).

Shahid, S., Kelson, J., & Saliba, A. (2024). Effectiveness and User Experience of Virtual Reality for Social Anxiety Disorder: Systematic Review. *JMIR Mental Health, 11*, e48916–e48916. https://doi.org/10.2196/48916

Slater, M., & Sanchez-Vives, M. V. (2005). From presence to consciousness through virtual reality. *Nature Reviews. Neuroscience, 6*(4), 332–339. https://doi.org/10.1038/nrn1651

Spence, S. H., & Rapee, R. M. (2016). The etiology of social anxiety disorder: An evidence-based model. *Behaviour Research and Therapy, 86*, 50–67. https://doi.org/10.1016/j.brat.2016.06.007

Stefaniak, I., Hanusz, K., Mierzejewski, P., Bieńkowski, P., Parnowski, T., & Murawiec, S. (2022). Preliminary Study of Efficacy and Safety of Self-Administered Virtual Exposure Therapy for Social Anxiety Disorder vs. Cognitive-Behavioral Therapy. *Brain sciences*, 12(9), 1236. https://doi.org/10.3390/brainsci12091236

Steinman, S. A., Wootton, B., & Tolin, D. F. (2016). Exposure therapy for anxiety disorders. In *Encyclopedia of mental health*. Academic Press. https://doi.org/10.1016/B978-0-12-397045-9.00266-4.

Stevens, T. M., & Sherrill, A. M. (2021). A Clinician's Introduction to 360° Video for Exposure Therapy. *Translational Issues in Psychological Science, 7(*3), 261–270. https://doi.org/10.1037/tps0000302

Strawn, J. R., Mills, J. A., Poweleit, E. A., Ramsey, L. B., & Croarkin, P. E. (2023). Adverse Effects of Antidepressant Medications and their Management in Children and Adolescents. *Pharmacotherapy*, 43(7), 675–690. https://doi.org/10.1002/phar.2767

Unity. (2022). Unity Engine. https://unity.com/products/unity-engine Accessed on 25.01.2024

Walter, H. J., Bukstein, O. G., Abright, A. R., Keable, H., Ramtekkar, U., Ripperger-Suhler, J., & Rockhill, C. (2020). Clinical practice guideline for the assessment and treatment of children and adolescents with anxiety disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, *59*(10), 1107-1124.

Wang, X., Young, G. W., Mc Guckin, C., & Smolic, A. (2021). A Systematic Review of Virtual Reality Interventions for Children with Social Skills Deficits. *2021 IEEE International Conference on Engineering, Technology & Education (TALE)*, 436–443. https://doi.org/10.1109/TALE52509.2021.9678808

Wolitzky-Taylor, K., Zimmermann, M., Arch, J. J., De Guzman, E., & Lagomasino, I. (2015). Has evidence-based psychosocial treatment for anxiety disorders permeated usual care in community mental health settings?. *Behaviour research and therapy, 72*, 9-17.

Wolpe, J. (1969). *The Practice of Behavior Therapy*, New York: Pergamon Press

Wong Sarver, N., Beidel, D. C., & Spitalnick, J. S. (2014). The Feasibility and Acceptability of Virtual Environments in the Treatment of Childhood Social Anxiety Disorder. *Journal of Clinical Child and Adolescent Psychology, 43*(1), 63–73. https://doi.org/10.1080/15374416.2013.843461

Wong, Q. J. J., Gregory, B., & McLellan, L. F. (2016). A Review of Scales to Measure Social Anxiety Disorder in Clinical and Epidemiological Studies. *Current Psychiatry Reports, 18*(4), 38–38. https://doi.org/10.1007/s11920-016-0677-2

World Health Organisation. (2023, September 27). *Anxiety Disorders* https://www.who.int/news-room/fact-sheets/detail/anxiety-disorders Accessed on 26.08.2024

Yang, Y., & Lu, X. (2022). Social anxiety and subjective quality of life among Chinese left-behind children: The mediating role of social support. *Frontiers in psychology, 13*, 836461. https://doi.org/10.3389/fpsyg.2022.836461

Zainal, N. H., Chan, W. W., Saxena, A. P., Taylor, C. B., & Newman, M. G. (2021). Pilot randomized trial of self-guided virtual reality exposure therapy for social anxiety disorder. *Behaviour Research and Therapy, 147*, 103984–103984. https://doi.org/10.1016/j.brat.2021.103984

APPENDIX A: SELF ASSESSMENT QUESTIONNAIRES

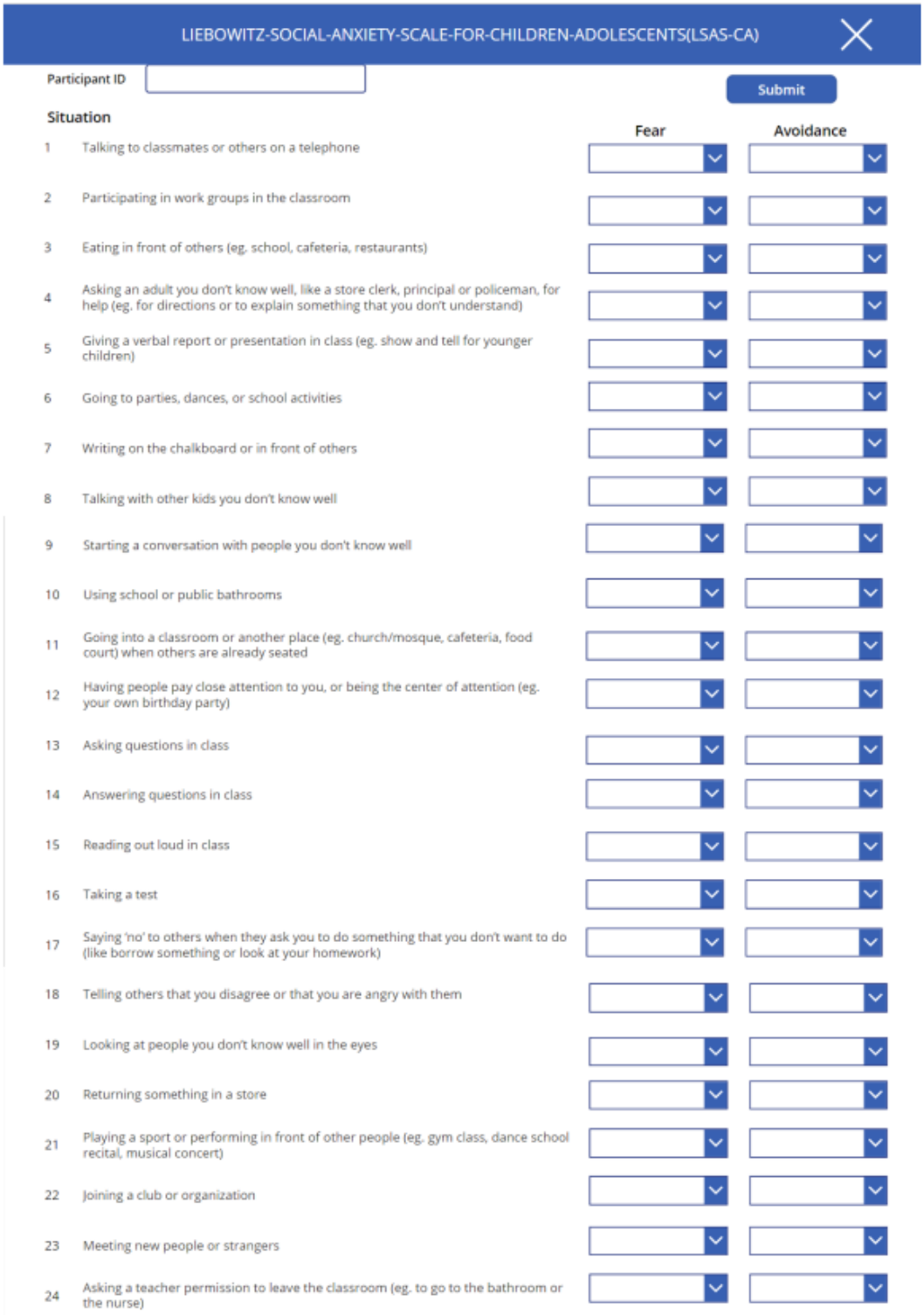

Figure 12. *Recreated online version of the Liebowitz Social Anxiety Scale for Children and Adolescents (LSAS-CA)*

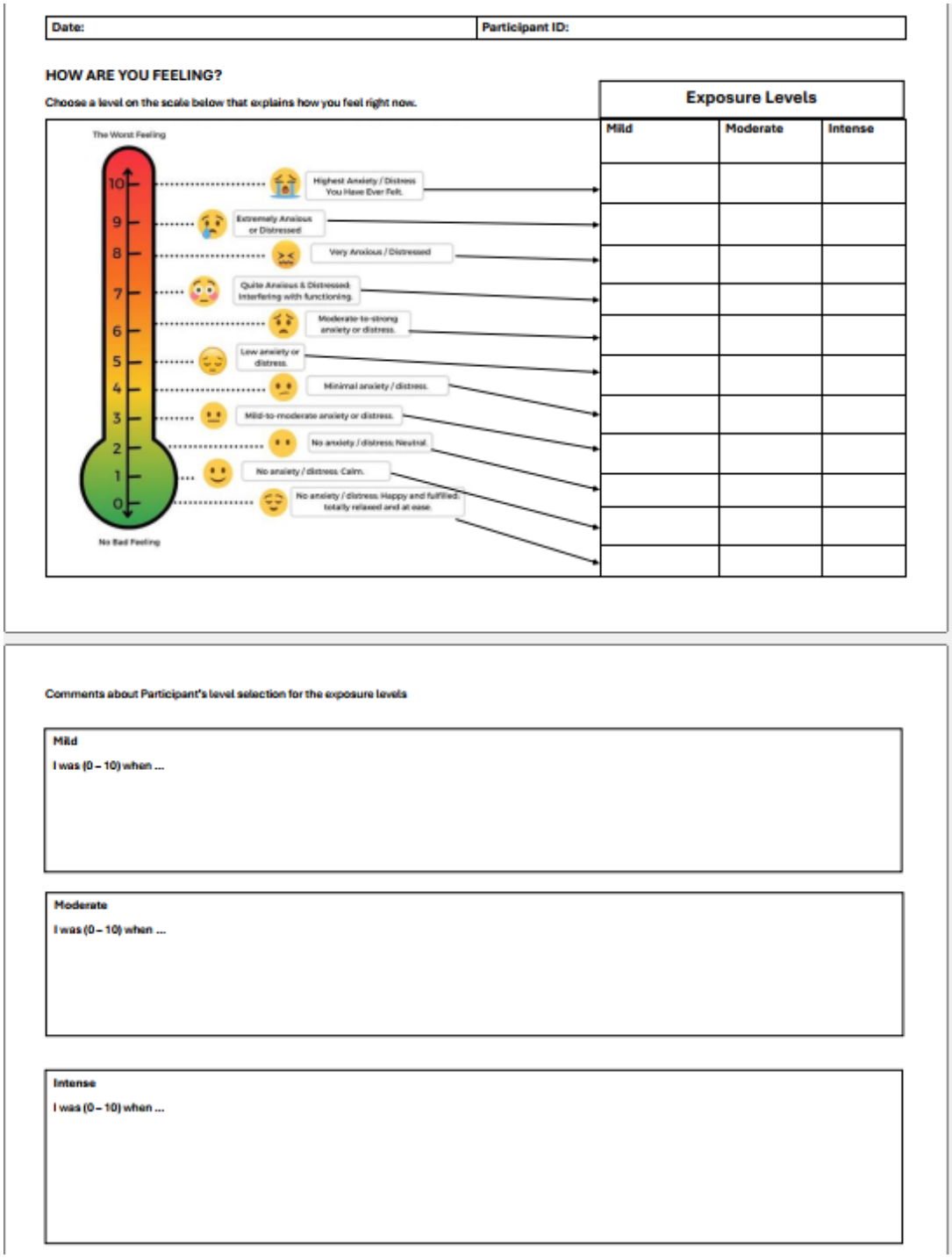

Figure 13. *Subjective Units of Distress Scale (SUDS)*

Please only check one circle in each line.

	1	2	3	4	5	6	7		*Comments per scale*
Attractiveness									
In my opinion, the product is generally									
annoying	○	○	○	○	○	○	○	enjoyable	
bad	○	○	○	○	○	○	○	good	
unpleasant	○	○	○	○	○	○	○	pleasant	
unfriendly	○	○	○	○	○	○	○	friendly	
I consider the product property described by these terms as									
Completely irrelevant	○	○	○	○	○	○	○	Very important	
Efficiency									
To achieve my goals, I consider the product as									
slow	○	○	○	○	○	○	○	fast	
inefficient	○	○	○	○	○	○	○	efficient	
impractical	○	○	○	○	○	○	○	practical	
cluttered	○	○	○	○	○	○	○	organized	
I consider the product property described by these terms as									
Completely irrelevant	○	○	○	○	○	○	○	Very important	
Stimulation									
In my opinion, handling and working with the product are									
not interesting	○	○	○	○	○	○	○	interesting	
boring	○	○	○	○	○	○	○	exciting	
inferior	○	○	○	○	○	○	○	valuable	
demotivating	○	○	○	○	○	○	○	motivating	
I consider the product property described by these terms as									
Completely irrelevant	○	○	○	○	○	○	○	Very important	
Usefulness									
I consider the possibility of using the product as									
useless	○	○	○	○	○	○	○	useful	
not helpful	○	○	○	○	○	○	○	helpful	
not beneficial	○	○	○	○	○	○	○	beneficial	
not rewarding	○	○	○	○	○	○	○	rewarding	
I consider the product property described by these terms as									
Completely irrelevant	○	○	○	○	○	○	○	Very important	

Figure 14. *User Experience Questionnaire Plus (UEQ+, a)*

Date:								Participant ID:
Visual Aesthetics								
In my opinion, the visual design of the product is								
ugly	○	○	○	○	○	○	○	beautiful
lacking style	○	○	○	○	○	○	○	stylish
unappealing	○	○	○	○	○	○	○	appealing
unpleasant	○	○	○	○	○	○	○	pleasant
I consider the product property described by these terms as								
Completely irrelevant	○	○	○	○	○	○	○	Very important
Intuitive Use								*Plausible means to be believable*
In my opinion, using the product is								
difficult	○	○	○	○	○	○	○	easy
illogical	○	○	○	○	○	○	○	logical
not plausible	○	○	○	○	○	○	○	Plausible
inconclusive	○	○	○	○	○	○	○	conclusive
I consider the product property described by these terms as								
Completely irrelevant	○	○	○	○	○	○	○	Very important
Social Stimulation								
In my opinion the use of this product is								
socially discouraging	○	○	○	○	○	○	○	socially encouraging
socially disengaging	○	○	○	○	○	○	○	socially engaging
socially neutral	○	○	○	○	○	○	○	socially empowering
socially exclusive	○	○	○	○	○	○	○	socially inclusive
I consider the product property described by these terms as								
Completely irrelevant	○	○	○	○	○	○	○	Very important

Figure 15. *User Experience Questionnaire Plus (UEQ+, b)*

APPENDIX B: RESEARCHER'S SEMI-STRUCTURED INTERVIEW

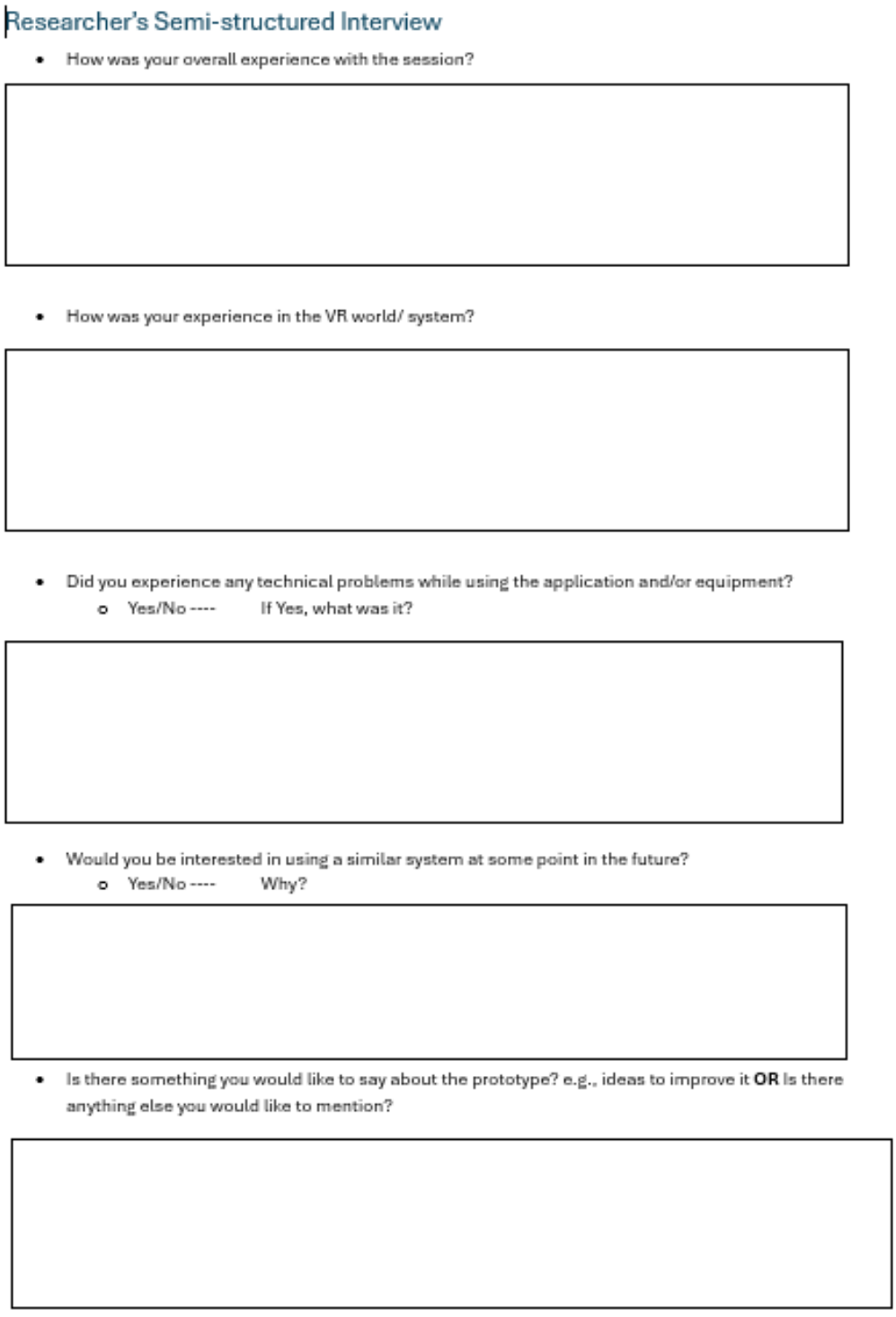

Figure 16. *Researcher's Semi-structured Interview Questions*