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**Vliv sociálního stresu ve virtuální realitě na emoční prožívání pacientů
s hraniční poruchou osobnosti**

**The Effect of Social Stress in Virtual Reality on Emotional Experience
in Patients with Borderline Personality Disorder**

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Prohlášení

Prohlašuji, že jsem diplomovou práci vypracovala samostatně, že jsem řádně citovala všechny použité prameny a literaturu a že práce nebyla využita v rámci jiného vysokoškolského studia či k získání jiného nebo stejného titulu.



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Abstract

The aim of this thesis is to explore the emotional reactions of patients with Borderline Personality Disorder (BPD) compared to a healthy control group when exposed to virtual reality (VR) scenarios depicting socially stressful situations. These scenarios include social cues, which are designed to trigger feelings like exclusion, rejection, or ignorance. They include both negative and neutral modalities in a train compartment and a bank lobby. The study investigates differences in coping strategies and the need for belonging between BPD patients and healthy controls. The sample consists of 21 healthy controls and 20 BPD patients. Using measures such as the Interpersonal Stress Coping Scale (ISCS) and the Need Threat Scale (NTS), significant differences were found in the need for belonging scores, with healthy controls scoring higher than BPD patients. This finding is discussed in the context of theories like Williams' model of ostracism and the concept of splitting in BPD. Non-significant results for ISCS scores suggest that the VR scenarios may not have been sufficiently provocative to elicit maladaptive coping mechanisms in BPD patients. Methodological considerations, such as the use of self-report measures and the nature of the VR scenarios, are discussed. The thesis concludes with recommendations for future research, including the use of additional measures.

Keywords: Borderline Personality Disorder (BPD), Virtual Reality (VR), Social Stress, Emotional Reactivity

Abstrakt

Cílem diplomové práce je prozkoumat emoční reakce pacientů s hraniční poruchou osobnosti (HPO) ve srovnání s kontrolní skupinou při vystavení scénářům virtuální reality (VR) zobrazujícím sociálně stresující situace. Tyto scénáře, které obsahují sociální podněty, které vyvolávají pocity vyloučení, odmítnutí nebo ignorování. Zahrnují jak negativní, tak neutrální modality ve vlakovém kupé a v bance. Studie zkoumá rozdíly v copingových strategiích a potřebě sounáležitosti mezi pacienty s HPO a zdravými dobrovolníky v kontrolní skupině. Součástí je 20 pacientů s HPO a 21 zdravých dobrovolníků. Pomocí měření, jako je Interpersonal Stress Coping Scale (ISCS) a Need Threat Scale (NTS), byly zjištěny významné rozdíly ve skóre potřeby sounáležitosti, přičemž kontrolní skupina dosahovala vyššího skóre než pacienti s HPO. Tento výsledek je diskutován v kontextu teorií, jako je Williamsonův model ostrakismu a koncept splittingu u pacientů s HPO. Nevýznamné výsledky pro skóre ISCS naznačují, že VR scénáře nemusely být dostatečně provokativní, aby vyvolaly maladaptivní copingové mechanismy u pacientů s HPO. Diskuze obsahuje metodologická hlediska, jako je použití sebehodnotících dotazníků a povaha VR scénářů. Diplomová práce je zakončena doporučeními pro budoucí výzkum, včetně použití dalších měření.

Klíčová slova: Hraniční porucha osobnosti (HPO), Virtuální realita (VR), Sociální stres, Emoční reaktivita

List of abbreviations

APA	American Psychological/Psychiatric Association
BSL-23	Borderline Symptom List, short version
BPD	Borderline Personality Disorder
C	Control Group
CSI-SF	Coping Strategies Inventory Short Form
DiS	Higher Professional Education (Czech abbreviation)
DSM-V	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
DERS	State Difficulties in Emotion Regulation scale
E	Experimental Group
ESM	Emotional States (items in the Subjective Units of Distress Scale)
ICD	International Classification of Diseases
IPQ	Igroup Presence Questionnaire
IPDE	International Personality Disorder Examination
ISCS	Interpersonal Stress Coping Scale
NFB	Need for Belongingness (subscale in NTS)
NIMH	National Institute of Mental Health
NTS	Need Threat Scale
PERS	Perth Emotional Reactivity Scale
SAPAS	Standardized Assessment of Personality Abbreviated Scale
SCID-II	Structured Clinical Interview for DSM Axis II Disorders

SSQ	Simulator Sickness Questionnaire
STIPO	Structured Interview of Personality Organization
SUDS	Subjective Units of Distress Scale
VR	Virtual Reality
VRET	Virtual Reality Exposure Therapy
WHO	World Health Organisation

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I. Theoretical section

Introduction

The presented thesis titled "The Effect of Social Stress in Virtual Reality on Emotional Experience in Patients with Borderline Personality" aims to explore how social stressors of daily life presented in a virtual reality (VR) environment affect the emotional experiences of individuals with Borderline Personality Disorder (BPD). This area of study is crucial because BPD is characterized by heightened emotional sensitivity, impulsivity, and unstable interpersonal relationships, which are often exacerbated by social stress. Utilizing VR allows for a controlled and immersive environment where specific social stressors can be simulated and studied in detail. By understanding how BPD patients react to these stressors, researchers can develop better therapeutic interventions tailored to their unique emotional and social challenges. Additionally, this research can provide insights into the ecological validity of VR as a tool for psychological assessment and treatment, potentially leading to more effective and accessible mental health care solutions.

The theoretical section is divided into three main chapters: characteristics of patients with BPD, explaining the social context of BPD and finally, BPD patients and social stress research in the VR. The first chapter provides an overview of Borderline Personality Disorder (BPD). It starts with the diagnostic criteria for BPD, explaining the main symptoms and behaviors of the disorder. Next, it discusses how to assess and evaluate these symptoms, describing different methods and tools used for diagnosis. The chapter also looks at differential diagnosis and comorbidity, showing how BPD can be distinguished from other mental health disorders and what conditions often occur with it. Finally, it reviews treatment options for BPD, including medication and therapy, and discusses how common the disorder is and its prevalence.

The second chapter investigates the interpersonal domain of BPD patients. It focuses on social cognition, covering topics such as mentalization or Theory of Mind, perceptual biases, and social problem-solving. The chapter then examines social stress and its effects on BPD patients, followed by an analysis of their emotional reactivity to social triggers. This detailed exploration of interpersonal issues provides a foundation for understanding how BPD patients interact with others and cope with social challenges.

The third chapter explores the use of virtual reality (VR) in the context of mental health. It discusses the emotional experiences that individuals have in VR environments and

the application of Virtual Reality Exposure Therapy (VRET). The chapter then looks into how social stress can be simulated and researched in VR, offering a unique perspective on stress reactions. Finally, it addresses the specific experiences of BPD patients in VR, including their social participation and how VR can be utilized to study and potentially treat aspects of BPD.

The empirical section of the thesis will provide an overview of the research goal, hypotheses, and research questions, establishing the foundation for the study. It will address ethical considerations, ensuring the research adheres to ethical guidelines. Detailed descriptions of the experimental scenarios and the measuring tools used in the study will be included, followed by a thorough explanation of the procedures undertaken. The section will also outline the statistical analysis methods employed to examine the data. Finally, it will present the results and engage in a discussion that interprets these findings in the context of the research questions and broader literature.

In this thesis it is cited according to APA, 7th edition (American Psychological Association, 2020).

1. Borderline personality disorder

The first evidence of the definition of borderline personality disorder was remarked in years of psychoanalytical studies when Kernberg and Gunderson defined borderline personality traits (Kernberg, 1975). Borderline personality disorder was however first established in the DMS-III (Biskin & Paris, 2012, Riegel et al., 2020). The term "borderline" was created by Stern to set apart patients who show similarities to both neurotic and psychotic conditions. This was necessary to distinguish them from individuals falling strictly into either category. Those patients labeled 'borderline' were typical for their masochistic behavior and psychic rigidity (Stern, 1938). Overall, the psychoanalytical approach of the BPD is based on assessing the dynamics of intrapsychic conflicts (Riegel et al., 2020). To conclude, psychodynamic thinking provides the anchoring of the borderline traits based on the phenomenological experience of the patients and it is further possible to include multiple diagnoses of the borderline type.

1.1 Diagnostic criteria for borderline personality disorder

Nowadays there are two main conceptualizations of borderline personality disorder being used in practice for its diagnostic criteria. These concepts are viewed as a categorical or descriptive approach and from the psychoanalytic point of view differ by viewing psychopathology as a set of clinically observable and classifiable phenomena. The International Classification of Diseases-10 (ICD; WHO, 2019) developed by the World Health Organisation (WHO) describes borderline personality disorder, respectively emotionally unstable personality disorder. Personality disorders involve impulsive behavior without considering consequences and unpredictable moods. These individuals often have emotional outbursts and struggle to control their actions, leading to conflicts, especially when their behaviors are restricted. Two main types are distinguished: the impulsive type, marked by emotional instability and lack of impulse control, and the borderline type, characterized by self-image disturbances, chronic emptiness, unstable relationships, and self-destructive behaviors like suicide attempts (WHO, 2019).

The ICD-11, the recent version of ICD and currently in the transition period has the view on personality disorders greatly changed. ICD-11 assesses personality disorders on a functional level in terms of degree of disturbance (WHO, 2024). The goal of the new system is to provide simplified descriptions based on dimensional domains instead of categorical prototypes. Those were rather complicated and complex to administer due to their requirement of knowledge of a wide range of signs and symptoms. Dimensional domains are related to the

research of the personality where the Big 5 is at the center of attention and are specifically established as the following trait domains: negative affectivity, detachment, dissociability, disinhibition, and anankastia (Costa & McCrae, 1992; Swales, 2022).

The process of the assessment requires firstly evaluating if the person's profile meets the personality disorder diagnosis at all, secondly, the severity is evaluated and then potentially the trait of the borderline can be specified. The main focus of the core features lies in disturbances in aspects of both self and interpersonal functioning and must be present for at least two years. Clinicians should assess whether self-dysfunction is represented as “persistent difficulties in maintaining a stable sense of identity, a pervasive sense of impoverished or highly overvalued self-worth, inaccuracies in self-perception or challenges in self-direction and decision making” (Swales, 2022). Regarding interpersonal functioning, difficulties can be spotted in “making and sustaining close relationships or in the ability to understand other people's perspectives as well as managing conflict in relationships” (Swales, 2022). In conclusion, these aspects of functioning affect the maladaptive patterns of cognition, emotional experience, expression, and behavior.

Emotional manifestations involve the range and appropriateness of emotional experiences and expressions, the tendency to be emotionally over- or underactive, and the ability to recognize difficult emotions like anger and sadness. Maladaptive cognitive patterns include accuracy in situational and interpersonal appraisals, decision-making under uncertainty, and the stability and flexibility of beliefs. Behavioral manifestations refer to impulse control, appropriate behavioral responses to intense emotions and stress, and the impact of these dysfunctions on personal, social, educational, and occupational functioning (WHO, 2024)

Furthermore, the severity ratings are evaluated in three possible dimensions - mild, moderate, or severe via several factors (WHO, 2024): The severity and extent of problems in a person's relationships and self-perception, the strength and range of their emotional, cognitive, and behavioral issues, the degree to which these patterns cause distress or social impairment, and the risk of harm to themselves or others.

Subsequently, the severity is assessed by the number of areas the person is affected and then the Mild, Moderate, or Severe Personality Disorder is estimated. Optionally, clinicians can involve additional descriptions of the type of difficulties of the patient. An additional factor called a borderline pattern specifier was involved in the theoretical background and is similar to the diagnostic criteria of DSM-V (Swales, 2022).

DSM-V offers another point of view for the systematic diagnostic criteria and is based rather on symptoms (APA, 2013). Patients with borderline personality disorder exhibit frantic efforts to avoid real or imagined abandonment, unstable and intense relationships that swing between idealization and devaluation, and a persistently unstable self-image. They display impulsivity in at least two potentially self-damaging areas, such as spending, sex, substance abuse, reckless driving, or binge eating. They also experience recurrent suicidal behavior or self-mutilation, affective instability due to mood reactivity, chronic feelings of emptiness, intense and inappropriate anger, and transient stress-related paranoid ideation or severe dissociative symptoms.

The diagnostic criteria for Borderline Personality Disorder (BPD) differ between ICD-11 and DSM-V. ICD-11 uses a dimensional approach, classifying BPD under personality disorders based on the severity of dysfunction and describing it within clusters. In contrast, DSM-V adopts a categorical approach with nine specific criteria for BPD, requiring at least five to be met for diagnosis. These criteria focus on identifying distinct symptoms and behaviors, ensuring consistency and reliability in clinical practice and research.

1.2 Assessment and evaluation of symptoms

Areas that need to be observed when assessing BPD are the following: emotional instability, ideational-identity disturbance, dissociation, interpersonal relationships, and behavior domains covering self-harm and impulsivity (Garland & Miller, 2020). Clinicians should indeed focus on chronicity as the history of presenting complaints is essential. This is mainly anchored in the standard psychiatric interview.

Firstly, the personality disorder should be assessed only when there is suspicion of a personality disorder. Rather easy screening interviews of 8 items can be used, mostly the Standardized Assessment of Personality Abbreviated Scale (SAPAS) (Garland & Miller, 2020).

One of many assessment tools is structured interviews or semi-structured interviews. One of the most reliable and valid was claimed by the Structured Clinical Interview for DSM Axis II Disorders (SCID-II; Carcone et al., 2015). Connected to the DSM classification, the Diagnostic Interview for DSM Personality Disorders (DIPD) was also remarked as valid and reliable, on the other hand, WHO developed the International Personality Disorder Examination (IPDE). Another DSM-V base assessment tool is The Zanarini Rating Scale for Borderline Personality Disorder (ZAN-BPD), which focuses more on the progress of

symptoms over time (Zanarini et al., 2003). The psychodynamic approaches utilize the Structured Interview of Personality Organization (STIPO). Although (Ferrer et al., 2018) find the SCID and STIPO as complementary tools as the STIPO correlates with DSM criteria robustly.

Lastly, the standard psychiatric assessment plays a role when evaluating symptoms of BPD. The structure includes dimensions of the characteristic of the complaint (emotional, cognitive, interpersonal, and behavioral), and the history of the complaint uncovering the chronicity (Garland & Miller, 2020). When mentioning the psychodynamic approach, countertransference is indeed one of the most important aspects as BPD patients bring out negative feelings like feeling incompetent, uneasy, and worried about being unable to assist the patient adequately, coupled with a sense of remorse when witnessing the patient's distress (Zanarini, 2013).

1.3 Differential diagnosis and comorbidity

Achieving precise psychiatric diagnoses is essential for effective treatment in clinical settings. Providing a BPD diagnosis can be challenging when reaching for accurate and reliable evidence (Carcone et al., 2015). However, the diagnosis of BPD might be seen as a “label” that could be seen as negative. Clinicians may hesitate to reveal a diagnosis of BPD out of concern that it could evoke pessimism in the patient (Lequesne & Hersh, 2004).

Borderline personality disorder overlaps several other diagnostic categories and is rather difficult as its symptoms are complex and generally based on communication with the patient about their observable signs (Paris, 2018). BPD is as many other characteristics for its changing moods (Biskin & Paris, 2012), impulsive reactions, lack of stability in relationships (Paris, 2018), low mood (Rao & Broadbear, 2019), hypomanic episodes (Gunderson et al., 2004), misperception of other people's intentions (Richman & Unoka, 2015).

Patients with BPD mostly fulfill conditions of depression, but the difference of the depression disorder is that depression is ongoing, i.e. is chronological, and is not responsive to current life events. Moreover, depressed patients are not as likely to show such a level of impulsivity and do not necessarily self-harm (Paris, 2018). On the contrary, BPD patients, eventually their depressive episodes are not responsive to antidepressants (Rao & Broadbear, 2019).

Some patients with BPD can exhibit symptoms of micropsychotic episodes consisting of auditory hallucinations in the form of voices urging them to commit suicide and how bad people they are (Paris, 2018). As Kelleher & DeVlyder (2017) studied hallucinations in BPD patients, the prevalence is only 1.3% which indicates a comparatively low occurrence.

When distinguishing between ADHD and BPD, the common factor in both disorders is impulsivity (Sebastian et al., 2014). It is necessary to differentiate between impulsivity in patients with BPD and ADHD as in BPD the impulsivity in behavioral areas can be seen mainly under stressful situations. The evidence for this difference was found by Sebastian et al. (2014) in the neurobiological context and areas of the prefrontal cortex affected. Paris (2018) however remarks that ADHD is mainly to be diagnosed in childhood or adulthood whereas BPD is stated in adulthood.

Childhood trauma is correlated with BPD as the origin of both is recognized in the early years of an individual (Paris, 2018). The confusion between BPD and PTSD can arise due to the significant role of traumatic experiences, whether they are singular or recurrent, including sexual, physical, or psychological trauma. These experiences serve as crucial factors in the development of severe personality disorders, particularly borderline personality disorder (Kernberg & Yeomans, 2013). However, the following symptoms can be found only in patients with BPD: frantic efforts to avoid abandonment, unstable sense of self, unstable and intense interpersonal relationships, and impulsiveness (Cloitre et al., 2014).

1.4 Epidemiology and prevalence

In the clinical environment, BPD is the most frequent personality disorder. (Oldham et al., 2010). A borderline personality disorder is prevalent in the general population, with estimated rates ranging from 1.4% to 5.9 %. However, this data comes from studies in primary care settings. (Aragonès et al., 2013). Other sources estimated the prevalence of 2 % in the general population (APA, 2013). Borderline personality disorder predominantly affects women, with an estimated gender ratio of 3:1, and it is observed across various cultures globally (Oldham et al., 2010).

From the ethological point of view, BPD is attributed to genetic and neurobiological factors as well as psychosocial factors (Siever et al., 2002). BPD might be dependent on heritability but we are not able to specify definite risk factors (Torgersen et al., 2000). The early experiences are however another potential factor.

1.5 Treatment of BPD

A negative context surrounding personality disorders, in general, can be identified, characterized by a perception that they are untreatable and carry a pessimistic prognosis. (Garland & Miller, 2020). On the other hand, several evidence-based methods were shown effective, mainly classified into two categories: based in cognitive behavioral therapy and psychodynamic therapy (Levy, 2020). The connecting factor of both is a long-term approach, high intensity of treatment and the therapist is competent in multiple techniques (Levy, 2020).

Recently, Dialectic Behavioral Therapy (DBT) has been the center of attention. Not only is it an evidence-based approach but it also was established by Marta Linehan who is a former BPD patient. DBT operates within team-based settings, requiring significant time commitment from both patients and clinicians. Its primary change mechanism lies in skill acquisition and its application to enhance emotional regulation and effectiveness in coping with individual sensitivities (Choi-Kain et al., 2017). Chanen et al. (2020) support the mechanism of DBT by proving that structured psychological interventions increase the efficiency of the treatment of BPD patients.

Schema-Focused Therapy (SFT) is a form of cognitive therapy to restructure a patient's personality. Same as the TFP, SFT promotes a strong bond between therapist and client targeting five schema modes of Borderline Personality Disorder (BPD) (Young et al., 2003): Abandoned Child, Angry and Impulsive Child, Punitive Parent, Detached Protector, Healthy Adult. The therapy style's purpose is to alter negative thinking, feelings, and behavior patterns, replacing them with healthier alternatives to regain control over the patient's life (Choi-Kain et al., 2017).

When mentioning psychodynamic conceptualization, Transference-Focused Psychotherapy (TFP) is based on interpersonal dynamics and works with transference and countertransference. As BPD tends to have problematic interpersonal relationships, psychotherapy focuses on relational dynamics and further emotional states coming from them. The goal of TFP is to help create a balanced view of self and others. TFP typically involves two individual therapy sessions weekly and encourages clinician supervision (Choi-Kain et al., 2017).

According to Mentalization-Based Treatment (MBT), Borderline Personality Disorder (BPD) symptoms emerge when individuals struggle to mentalize, leading to fixed beliefs about others' intentions, detachment from reality, and reliance on actions to validate emotions. MBT

aims to address BPD symptoms by enhancing patients' ability to mentalize, encouraging curiosity and adaptability in how they perceive and navigate emotions and relationships (Choi-Kain et al., 2017).

To sum it up, psychotherapy is the most suitable approach to treating BPD. Levy (2020) claims that even though DBT gained a lot of research attention, it is not significantly effective in comparison to other approaches.

2. Interpersonal domain of BPD patients

Disruption of interpersonal relationships is one of the most significant symptoms of BPD (Gunderson, 2007; Hill et al., 2008; Lazarus et al., 2014). Although the vast majority of patients achieve remission over time, severe impairment in psychosocial functioning often persists during a lifetime (Gunderson, 2011). Not only close relationships of BPD patients are affected but also daily casual encounters in an anonymous environment, however, the assumption is that the more intimate the relationship the patient has, the more maladaptive symptoms are demonstrated (Garland & Miller, 2020). Therefore, the interpersonal dynamics of BPD patients manifest in emotion regulation and affective instability, regarding clinical symptoms in recurrent self-injury, impulsive aggression, and chronic risk of suicide (Domes et al., 2009). In this thesis, we are focused mainly on BPD patients as receivers of social context rather than emitters, even though abilities in this area are also typically reduced (Roepke et al., 2013).

The interpersonal domain of BPD can be split into three subdomains when mentioning certain deficits or disruptions. Firstly, the perception of social aspects in BPD patients will be described as social cognition (Lazarus et al., 2014), BPD patients tend to fail in facial emotion recognition cognitive processes (Domes et al., 2009) or reading social cues in general (Roepke et al., 2013). Secondly, the reduced ability to interpret social situations and react to social cues (mainly social triggers and stressors) also strongly contributes to social dysfunction in BPD (Lazarus et al., 2014; Roepke et al., 2013). The third subdomain can be recognized as applying social information that is manifested in inappropriate emotional arousal (Domes et al., 2009; Houben et al., 2018), poor ability to generate effective strategies for controlling thoughts and feelings (Bateman & Fonagy, 2010), and eventually impulsive behavior (Domes et al., 2009; Lieb et al., 2004).

To conclude, disturbed social cognition, reduced ability to interpret social situations, and application of social information can be studied in BPD patients. The research focus of the thesis is primarily focused on the perception of social cues evoking social stress and further emotional responses of patients. Therefore, mechanisms of social cognition of social stress in the context of BPD patients will be described as well as expected emotional responses.

2.1 Social cognition

Social cognition is an essential psycho-social phenomenon to explore regarding BPD patients as empirical research consistently proves that they tend to be biased in a mental state attribution. According to Roepke et al. (2013), social cognition is the “sum of cognitive processes that allow humans to interact with one another substantially depending upon the exchange of social signals”. Other authors use a more elaborate definition: “sum of mental processes associated with the perception and interpretation of stimuli pertinent for social interaction as well as with the response to these stimuli” (Andreou et al., 2015; Bell et al., 2010). We will briefly describe the most relevant social cognition theories to understand social cognition in BPD patients.

2.1.1 Mentalization or Theory of Mind

According to Fonagy, “mentalization is the process by which we make sense of each other and ourselves, implicitly and explicitly, in terms of subjective states and mental processes” (Bateman & Fonagy, 2010). What is more, mentalization is seen as a social construct because the individual pays attention to the mental states of others. Poor ability for mentalization can be associated with disorganized attachment showing in emotion dysregulation and lack of control. Robust mentalizing capacity therefore could not be developed as understanding of others depends on understanding the individual's mental state by the primary caregiver (Bateman & Fonagy, 2010).

Sharp et al. (2011) refer to mentalization as the theory of mind. Theory of Mind (ToM) is defined as an “understanding of how humans reason about mental states by utilizing shared world knowledge, social cues, and the interpretation of actions” (Byom & Mutlu, 2013). The concept Sharp et al. (2011) studied regarding mentalization in adolescent BPD patients. 'It denotes the collection of intuitive ideas that all of us possess concerning mental functioning and the nature of perceptual experience, memory, beliefs, attributions, intentions, emotions, and desires.

BPD individuals would more likely overmentalize than lose their capacity at all. The loss of mentalization is possible mainly in patients with psychotic structures, but it is not a common strategy for BPD. This is supported by the research of Burghardt et al. (2023) claiming that BPD individuals are characterized by exceeding Theory of mind. On the contrary, Betenon and Fonagy refer to a lower capacity to mentalize in BPD patients instead of the

exceeded capacity. However, authors addressed certain problematic issues in mentalization, assuming a loss of mentalizing, but following evidence-based research had proved oppositely (Bateman & Fonagy, 2010; Burghardt et al., 2023; Sharp et al., 2013)

To specify, it is claimed that the issue with mentalization in BPD patients lies in over-mentalizing (Andreou et al., 2015; Sharp et al., 2011, 2013). The predicting factor of overmentalizing is overconfidence in errors and attention or working memory (Andreou et al., 2015). As social cognition is essential in correct reading and interpreting social cues, we will further discuss the differences between BPD patients and healthy populations.

2.1.2 Perceptual biases

Domes et al. (2009) claimed concerning BPB recognition of emotions tendency of BPD individuals to attribute emotions more negatively, with stressed sensitivity towards actual negative emotions, which confirms the fact described by Wagner and Linehan, that patients with BPD often tend to be triggered by the signs of social threat and rejection. (Wagner & Linehan, 1999). Fonagy (1991) describes their inappropriate intense reaction, which is usually triggered by criticism and rebuff. Not only valence of perceived cues is influenced but also intensity, BPD patients report more extreme judgments about others (Andreou et al., 2015). To summarize, BPD patients have reduced cognitive empathy, e.g. inferring emotions, thoughts, and intentions in the social aspect.

What is more, BPD patients might lack the ability to read and interpret social cues, possibly because of over-mentalizing (Andreou et al., 2015). Domes et al. (2009 remarked) that the capability to adequately infer the mental state of others from the cues from emotional expressions is basic to adapting an individual's behavior and emotional state within the social context. This is supported by Marsh et al. (2007) who claim that the potential of recognizing between internal state and external cues forms the basis for prosocial behavior, the capacity for empathy, and trust. Overall, this ability plays an essential role in social functioning. (Domes et al., 2015). As mentioned above, BPD patients are receivers of social signals they are disadvantaged because others are seen as rather malevolent. This phenomenon was supported by the study of Veen and Arntzs (2000) who studied emotional reactions towards movie clips, they asked BPD and healthy controls to assess actors. The authors aimed to evaluate whether BPD patients are related to more extreme or negative ratings of scenes specifically related to BPD triggers. Finally, BPD patients had more extreme categorization of others considering situations like rejection and abandonment (Veen & Arntz, 2000).

2.1.3 Social problem-solving

Lazarus et. al (2014) notes another theory concerning social cognition: social problem-solving. This aspect refers to the ability to respond to common issues within daily social interactions flexibly. Social problem-solving is tightly related to the Theory of mind because it also requires an ability to understand the social context adequately. This is illustrated in the study where authors compared solutions of The means-end problem-solving task and BPD patients showed less relevant solutions, inefficient and not specific solutions than participants from the healthy control group (Bray et al., 2007). An important role plays in the emotional context when BPD patients face social problem-solving tasks because BPD patients typically fall for negative emotional bias and this could prevent being specific and efficient when finding solutions to interpersonal conflict.

2.2 Social stress

Social interactions represent a major part of daily life as they are interactions purposefully sought by people (Baumeister & Leary, 1995). However, they can contribute to experiences of stress and discomfort due to their situational and dispositional character (Rubo & Munsch, 2024). In the study of Deckers et al. (2015), it was claimed that patients with BPD might have experienced negative emotions in reaction to social stress more likely than healthy controls. However, BPD patients reported increased negative subjective emotional states even though their biological feedback was rather fluctuating. What is more, patients are experiencing social threats even in neutral social situations. Ostracism is therefore an essential phenomenon regarding social stress in BPD.

Generally, one of the methods on how social stress can be tested is the Trier Social Stress Test (TSST) in which explicit stress is tested, like delivering a speech and counting a mathematical example in front of the audience. The resulting scores are examined in areas of concentration of ACTH, cortisol, or heart rate (Kirschbaum et al., 1993).

From the physiological point of view, BPD patients show increased cortisol responses in interpersonal encounters, especially within social stressors. Considering situations of social exclusion, they manifested increased neural activation in the left medial prefrontal areas. As mentioned before, patients with BPD manifest self-reporting more intense emotional reactions like negative affect or anger when experiencing interpersonal stressors. They seem rather sensitive towards feelings of exclusion, and generally, situations where emphasized

participation are reported as more stressful even though it is not dependent on the feeling of inclusion or exclusion (Lazarus et al., 2014).

In this study, we focus on the daily subtle stress (or daily hustles), which does not focus on explicit stressors like public speaking or performing in front of an audience. It is rather based on common situations of daily life. Conditions of daily life influence BPD patients considering the aversive tension occurs faster, more frequently, and in longer intensity. Triggers they noticed are mostly feelings of rejection, being alone, and failure (Stiglmayr et al., 2005). Tragesser et al. (2008) also specify that regardless of the source - being triggered by close ones or strangers- they would feel a more intense reaction compared to healthy controls. Bungert et al. (2015) add that a possible source of rejection sensitivity might be low self-esteem.

2.3 Emotional reactivity in the context of social triggers

When BPD patients encounter rather negative situations, they tend to make intense judgments while having only poor evidence. This could be seen as a cognitive bias leading to jumping to conclusions (Huq et al., 1988). The research study of the emotional reactivity in the daily life of BPD patients showed that they are more likely to experience increased emotional reactivity with negative emotions especially when being disappointed by others. On the other hand, reduced reactivity when experiencing positive emotions regardless of the relevance of the triggering situation. These research results partially support the notion that when faced with a social stress scenario, people tend to perceive others more negatively, seeing them as unreliable or hostile (Hill et al., 2008). Houben et al., (2018) supported this by researching the emotional reactivity to appraisals in daily life in patients with BPD. When an event is evaluated as disappointing or an encountered person is mistrusted, patients with BPD tend to react more intensively. This was tracked by the personal notes of patients who were alarmed during the day to write down their current attitude and its context.

Schematherapy takes into account social triggers and emotional arousal. It uses the metaphoric tools of schemas and modes for describing personality and its defense mechanisms or patterns repeated in a lifetime. This formed the main framework of thought behind the created scenarios in virtual reality. The empirical part of the thesis will be further dedicated to describing them specifically, however in this section, we would like to explain some main concepts anchoring the scenarios in theory. Schematherapy addresses the early emotional needs of an individual and infers a person's behavior if early needs are unfulfilled. Therefore, when aiming for the emotional reactions of BPD patients, schematherapy concepts were involved.

Regarding the treatment of BPD, schematherapy is often noted as a suitable form of psychotherapy due to its relationship-based and early schemes approach. The schematherapy model includes four types of concepts:

Early Maladaptive schemas could be understood as patterns that an individual repeats throughout life. Accordingly, schemas relate to early emotional needs, and oftentimes they develop into maladaptive patterns due to their unfulfillment in early childhood. *Early emotional needs* include five basic emotional needs that are essential for sufficient emotional development. *Maladaptive coping styles* are described as types of adaptation to schemas and triggering early experiences. Finally, *schema modes* cover the combination of emotions and coping mechanisms, usually, it shows up when being triggered by an individual and specific situation.

When mentioning triggers like abandonment, social exclusion, or feelings of ignorance, Young has identified five main modes in patients with BPD: abandoned child, angry and impulsive child, punitive parent, detached protector, and healthy adult.

To sum it up, an abandoned child mode reflects a patient's feelings of helplessness and loneliness, with the obsession of finding a parent figure who will provide care to them. In this mode, they would like to be treated like a young, innocent, and dependent child with strong tendencies to idealize their caretaker. The second listed above is an angry and impulsive child, which suggests that it is an uncontrolled venting of emotions, mainly anger. In this mode, they might be devaluing, controlling, and abusive. What is important to emphasize is the tendency to act impulsively and manipulatively. Punitive parent subsequently described the mode when a BPD individual punishes them for expressing needs and feelings, which is perceived pejoratively. This mode stands for the internalization of caregivers' rage, hatred, or even abuse leading to becoming their punitive parent. This mode has the paradoxical premise that a patient becomes angry with themselves because of showing a normal and adequate need that was not fulfilled in childhood. In the detached protector, it is common for BPD patients to repress their needs and follow every psychotherapist's instruction to pretend to be 'good'. Lastly, the healthy adult refers to a general mode of managing schemes together (Young, 2003). This should support an understanding of the schematherapeutic perspective on emotional arousal in BPD patients. According to the cognitive model of Young (2003), it is presented evidence of assumptions of a fear of rejection being specific to BPD patients (Arntz et al., 1999; Renneberg et al., 2005).

Rejection is a key trigger to study in the context of BPD patients. Chapman et al. (2015) documented the effect of social reflection on individuals with high levels of borderline personality features. Results showed increased hostility and reactivity to social rejections. The most common reaction is therefore anger. On the other hand, feelings of shame did not increase.

In all, the anticipated reactions of patients in this research may be feelings of anger, impulsivity, they may feel abandonment or anxiety. We can also assume feelings of shame and inadequacy. Additionally, the intensity of the emotions listed may be increased compared to healthy volunteers.

3. Virtual reality in the context of mental health

Virtual reality (VR) is rapidly evolving in terms of quality and real-like experience and is also providing numerous applications and developments in the mental health field. The non-disputable benefit of virtual reality exposure therapy is that it simulates a natural environment. The administrator can control and operate it, creating satisfactory conditions for research, therapy, and targeted treatment (Meyerbröker & Morina, 2021). Even though the environment in VR is controllable it has the potential of high ecological validity (Bell et al., 2010). To conclude, virtual reality allows participants to be in a computer-generated environment where they can interact with objects or avatars. The virtual environment is 3D displayed (Gorini & Riva, 2008).

As mentioned above, the most significant advantages of VR are controllability and immersivity. Ecological validity is defined as the degree to which the findings of research studies generalize to real-world settings (Parsons, 2015). This is given by immersion in the environment: pictures are displayed three-dimensionally, continuously rendered relatively to the position of the viewer, and allowing the viewer to explore the virtual situation almost fully. Also, not only participants can have the real feeling of the observation, but they can also interact with objects in the given elements in the scenario. This suggests a rather real-like sensation than a plain viewing of pictures or imagining certain situations. Therefore, virtual reality allows us to picture daily life scenarios. In addition, controlling and manipulating the virtual environment is another relevant aspect as well as personalization and tailoring (Bell et al., 2020).

Consequently, collecting data is rather efficient and simple because VR technology oftentimes allows the capturing of data via eye tracker or tracking other physiological measures. From the point of view of the participant, VR increases engagement in the testing situation. This helps when psychological procedures are lengthy or repetitive and can be utilized especially in cognitive and performance testing. Participants in the VR can experience the feeling of 'presence', the specific term referring to the subjective feeling of being in one place when physically situated elsewhere (Slater & Sanchez-Vives, 2016). Accordingly, the participant's engagement is influenced by the sense of presence. Besides that, the aspect of gamification affects the VR experience through the utilization of digital games. As such, tools like rewards, and providing feedback on the performance i.g. can improve individual engagement.

A possible drawback of using VR in the mental health field might be the engagement and motivation of patients to undergo 'distrusted' and unknown technology. (Meyerbröker & Morina, 2021). Another uncomfortable phenomenon using virtual reality is cybersickness. This is defined as a 'form of simulation sickness experienced when using head-mounted displays' (Ramaseri Chandra et al., 2022).

However, the use of VR in therapy and mental health research has been at the center of attention for about 25 years (Slater & Sanchez-Vives, 2016). In light of that, VR was claimed as effective in treating anxiety disorders via VRET (Diemer et al., 2015; Freeman et al., 2017). The range of patients' target groups is rather large, we can find several studies focused on OCD (Dehghan et al., 2022; Fajnerová et al., 2023; Javaherirenani et al., 2022), phobias focused on fears of heights, spiders, contamination, etc. (Mühlberger et al., 2007; Rimer et al., 2021), social phobia (Hartanto et al., 2014; Kampmann et al., 2016), schizophrenia (Freeman, 2008; Hesse et al., 2017), general anxiety disorders and depression (Anderson et al., 2013; Carl et al., 2019; Kampmann et al., 2016; Zeng et al., 2018), and eating disorders (Gorini & Riva, 2008).

To summarize, virtual reality in the context of mental health owes its applicability to ecological validity, immersive features, rather easy data collection, and enhancing high engagement in participants. According to Bell et al. (2020), the main research areas of VR in the context of mental health are social functioning, cognition, and symptomatology. Regarding social functioning, a key area of the thesis, most commonly the data is collected via eye tracking, measuring the proximity to the avatar in the scenario, or via the recording of the reactions. However, this thesis is focused on emotional reactions measured by questionnaire

battery. On the other hand, the essence of the vast majority of social studies is kept, comparing the reactions of experimental and healthy-control groups of participants.

3.1 Emotional experience in VR

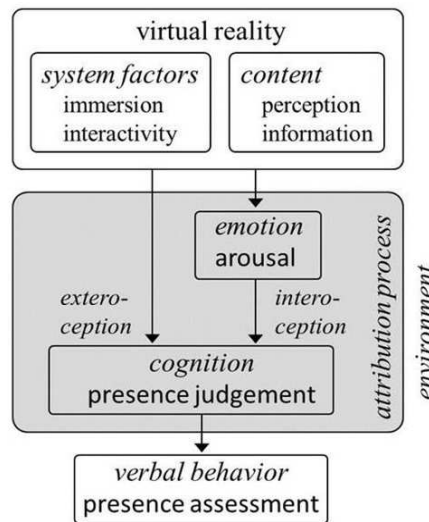
When seeking to enhance the realism of virtual reality experiences, a key question arises: Can virtual reality effectively evoke emotions? According to Bell et al. (2020), virtual reality influences physiological changes and therefore emotional responses corresponding with scenarios of the real world. For research purposes, it is possible to observe symptoms like paranoia, cravings, anxiety, and fear triggered by cues in the VR. Even though VR is an artificial environment, visual cues or sounds can trigger an emotional reaction via perceptual stimulation (Diemer et al., 2015).

To better understand the effect of virtual reality on emotions, it is necessary to describe a few potential VR mechanisms. A significant aspect of the emotional experience in VR is often claimed to be a fundamental phenomenon (Parsons, 2015; Price et al., 2011). As mentioned above, presence refers to the subjective feeling of being in one place when physically situated elsewhere (Slater & Sanchez-Vives, 2016). However, Diemer et al. (2015) state that the relationship is debatable and their hesitation is based on how one measures the construct of presence in VR. The construct of presence can be influenced by using more advanced technology or by the type of measurement. In their perception, presence is defined as a subjective phenomenon that results from experiences induced by immersive VR technology. A more adequate naming for the case of using more advanced technology is therefore *manipulation of immersion* rather than a presence. To conclude, presence is by far strongly supported as a significant correlation of emotional experience. Interestingly, the stronger the valence of emotions is experienced or as the group of patients is emotionally imbalanced, the stronger the correlation is. Freeman (2005) argues this is given by the *arousal theory* of presence. This point explains that arousal influences the level of one's alertness and therefore the subjective feeling of presence (Freeman et al., 2005).

As the technology is more graphically evolved, the level of presence would be higher. Most studies confirm this fact with the addition that less emotionally charged situations promote a greater sense of immersion (Baños et al., 2004; Diemer et al., 2015). Therefore, immersion might also affect emotions in VR as shown in *Figure 1*. Nonetheless, studies provide multiple results stating either increasing emotional responses in rather immersive

environments, some suggest that it is related to the characteristic of the studied emotion (e.g. fears or positive emotions of relaxation or joy) (Diemer et al, 2015).

Figure 1: An interoceptive attribution model of presence (Diemer et al., 2015)



3.2 Virtual Reality Exposure Therapy (VRET)

As the goal of this thesis is to compare emotional reactions after triggers in virtual reality, in this chapter we will describe the Virtual Reality Exposure Therapy mechanism. Regarding clinical practice, Virtual Reality Exposure Therapy (VRET) can be used with patients with anxiety and other similar disorders. Thus, in the social domain, social anxiety disorders have been studied (Meyerbröcker & Morina, 2021). VRET provides a controlled environment of feared triggers which is safe and still keeps the conditions of the clinical setting (Bell et al., 2020, Freeman et al., 2018). Just as in *in vivo exposure therapy*, individuals undergoing VRET are systematically exposed to increasingly anxiety-inducing stimuli, progressing from the least to the most anxiety-provoking stimulus (Gorini & Riva, 2008). VRET is considered as not significantly different from *in vivo exposure*. Also, in the comparison of the effect size (Carl et al., 2019). Price & Anderson (2007) mentioned the necessary conditions for successful treatment in VR, the presence and immersion are essential, although by increasing both the exposure therapy effects do not arise.

VRET is based on the same cognitive and affective system as the original exposure therapy. Craske et al. (2014) explain the underlying mechanism as an *inhibitory learning model* considering anxiety disorders in exposure therapy. This suggests that patients would learn in the exposure therapy about the consequences of their feared stimuli, e.g. that it probably would

not happen. However, Meyerbröker & Morina (2021) question this claim as they see rather obvious that some feared outcomes can not occur in VR which might affect the expected learning curve. Historically, VRET was also anchored in the *emotional processing theory* (EPT) represented in the theory that the initial activation of the anxiety network must occur before habituation can happen both within and between sessions. This was shown in the study of the fear of heights, authors compared exposure in vivo and prolonged exposure. They remarked that there is a certain difference in experiencing anxiety in VR and in vivo, but the effect of the therapy in both is rather the same (Emmelkamp et al., 2002). EPT was originally explained by Foa & Kozak as a memory network including details about the characteristics of feared stimuli, and eventual plan of how to avoid them, i.g. fear response and direct association with the threat (Foa & Kozak, 1986).

What is more, researching fear reactions, both perceptual fear cues and conceptual information are relevant triggers of fear reactions (Diemer et al., 2015). According to Strack and Deutsch (2004), this is influenced by the *impulsive-reflective model of social behavior*. The model explains the effect of the perception as well as information on fear. Authors suggest that emotional reactions are fast and influenced by the laws of association whereas reflective behavior tends to be flexible and under cognitive control. Typically, emotional and impulsive systems interact, at first conceptual information activates the emotional reaction. To conclude, VR is beneficial in the field of research due to its ability to directly include feared subjects as well as offer contextual meaning. Contextual meaning might be demonstrated in the laboratory setting outside the virtual environment or by pre-education of the participant about possible feared objects in the environment.

Another aspect related to social anxiety disorder and exposure therapy is a concept called *self-efficacy*, which represents the trust in oneself to execute adequate behavior. A research study focused on social anxiety disorder proposed that self-efficacy was related to the outcome of the treatment but did not predict the improvement. Overall, the level of self-efficacy significantly impacts the patient's will to undergo the exposure, reduces the tendency to avoid triggers, and expands the awareness of one's abilities. This is supported by a study by Kampmann et al. (2016)

Besides VRET, Freeman et al. (2008) defined 7 areas of the purpose of VR in mental health: Assessing symptoms, identifying markers or correlates of symptoms, establishing predictive factors for disorders, testing potential causal factors, exploring the differential prediction of symptoms, examining environmental toxins, and developing treatments (Freeman et al., 2008).

3.3 Social stress in VR

The first research studies focused on social stress were focused on patients with social phobia or social anxiety disorder. Although it might be challenging to address the real-like experience considering humans in the virtual scenes, it was shown that artificial avatars in the environment impact the individual phobic experience (Pertaub et al., 2001). Since then, several research studies have been conducted regarding explicit social stress (Hartanto et al., 2014; Hesse et al., 2017; Kampmann et al., 2016).

Hartanto et al. (2014) conducted a study based on the social dialogue situation and social dialogue feedback responses in both negative and positive types between human and virtual characters. Results showed that there is a difference in reported anxiety and heart rate in every scenario. The more perceived the dialogue was, the less anxiety was noted. This should illustrate that VR is an appropriate environment for manipulating social triggers for therapeutic purposes.

Hesse et al. (2017) offered a perspective on the experience of social stress in patients with psychotic disorders when exploring the effects of social rejection. Participants underwent an experiment where they participated in a virtual office and were asked to help or refused to cooperate. Results showed utilizing virtual reality (VR) for evaluating the impacts of social rejection is both feasible and well-tolerated by the majority of patients.

Explicit social stress in VR includes situations like speaking in front of an audience, small-talk with strangers, going shopping and returning goods, attending a job interview, or going on a blind date. The task of participants in this study was to verbally react to artificial avatars in scenarios (Kampmann et al., 2016). The authors documented the positive therapeutic effect of VRET on individuals with SAD when facing socially triggering situations.

On the other hand, when studying daily stress without the emphasis on explicit stress, Veling et al. (2016) documented the effect of social stress reactivity in VR on patients with childhood trauma. Importantly for this thesis, participants were exposed to the environmental social stress given by the higher number of avatars playing visitors in the virtual café, their appearance, and their facial expressions. Presented results supported the premise that social stress even in the level of daily hustles and everyday normal stress is a significant trigger of dysregulated affective reactions in patients with childhood trauma (Veling et al., 2016)

Diemer et al. (2015) draw attention to the empirical findings on cues that trigger social phobia. They compared the effect of *conceptual information* and *perceptual cues*, claiming that perceptual cues are more evident in specific phobias (e.g. arachnophobia) and contextual information is more relevant for social phobia. The nature of social phobia is based more on the cognitive perception of the situation, so it is expected that just knowing that participants will be performing in front of people will be more triggering than seeing people live. Also, real observers outside the VR are likely to cause significant arousal due to the nature of social phobia. However, this premise was not significantly recognized.

To conclude, social stress in its explicit modus (e.g. public speaking, asking strangers a favor, etc.) is often studied in virtual reality, usually in the VRET on patients with social phobia. Although the characteristics of social stress in social phobia patients are rather different than in BPD patients, research knowledge can still support the relevance of studying social stress in VR. To complete, social stress in social phobia is based on the fear of being judged negatively by others and being embarrassed in social situations (Hartanto et al., 2014) whereas social stress in BPD patients is related to feelings of abandonment, rejection, and following emotional dysregulation manifested in anger and impulsivity (Garland & Miller, 2020).

3.4 BPD patients in VR

Patients with BPD tend to suffer from conflicts in interpersonal relationships and psychotherapy is oftentimes presented as the most efficient form of psychological help in this area. With the increasing popularity and stable VR research in mental health care, there is an opportunity to explore alternative methods for practicing interpersonal situations. Studying social stress in virtual reality and its influence on patients with BPD is not very widespread in research studies though. Given that, researchers focus on several other possible utilizations of VR within BPD patients: psychotherapy, relaxation, or research of social acceptance. This chapter will briefly summarize previous knowledge about research on BPD patients in VR.

An experimental study by Liebke et al. (2018) included BPD patients in the VR and through the Mannheim Virtual Group Interaction Paradigm (MVGIP) assessed expectations of BPD patients being included in social situations. Authors suggest that BPD patients have lower expectations of social acceptance in comparison to healthy controls. Regarding an adaptation of expectations on social feedback, the BPD group of patients did not react more socially accepted after positive feedback, but on the other hand, did not react more negatively to the

rejection. What is more, even when others accepted BPD patients in the VR, they behaved less cooperatively. The rejection also did not trigger any aggression or increase in cooperation.

Falconer et al. (2017) presented a research study focused on the mentalization-based treatment (MBT) of BPD patients in the VR. The key factor of MBT is helping a patient to understand their experience of an interpersonal event with an additional focus on understanding possible experiences and mental states of others in the encounter. The therapist supports the understanding by constructing and reconstructing past encounters via exploring several possible interpretations of the mental states of participants. In this study, virtual avatars played a role in the VR environment aiming to represent the patient's self and encounter others together with a symbolic representation of each participant's thoughts in a social situation. The virtual environment helped patients to become aware of and empathize with their fellow participants, allowed them to see the situation in a bigger picture, and provided them the distance to think without intrusive emotional reactions (Falconer et al., 2017).

3.4.1 Social participation in VR in the context of BPD

The virtual tossing game Cyberball is an experimental paradigm where social inclusion and exclusion or *ostracism* are studied. This game allows players in virtual reality to throw and catch a virtual ball within a group of other players (maybe also virtual). The experimental environment can be artificially controlled and can induce social inclusion and exclusion (Renneberg et al., 2012; Williams & Jarvis, 2006). The experiment's controllable components are the game's speed, frequency of inclusion, player information, and iconic representation (Williams & Jarvis, 2006).

Renneberg et al. (2012) compared the reactions of healthy controls and BPD patients. Authors suggest that distorted perceptions of participation in social situations and impulsive emotional reactions contribute to dysfunctional relationships. BPD patients demonstrated stronger anger when feeling socially excluded. Interestingly, levels of sadness were reduced due to simply participating in the game. Patients with BPD claimed to be less involved in the game even though the amount of ball throws was the same for every participant (Renneberg et al., 2012; Williams & Jarvis, 2006). Not only did they feel socially excluded but they also described negative self-focused emotions e.g. sadness and loneliness both before and after they played Cyberball. The direction of emotions changed after the experience of exclusion, they

started being more resentful and angry compared to the healthy control group (Staebler et al., 2011).

Given that, Rubo & Munsch (2024) demonstrated the effect of ostracism on increased subjective stress as well as negative mood. Nonetheless, social stress resulting from ostracism in Cyberball studies was only moderate compared to the effects of ostracism in daily life. A possible explanation might be only a brief moment of ostracism in the game followed by the effect of avatars in the game, which are visibly different from real humans. In contrast, previous research showed that individuals experiencing virtual ostracism may feel negative emotions similar to those of real-life ostracism (Kassner et al., 2012).

Interestingly, Williams introduced a model of threatening fundamental needs connected to feelings of ostracism, social exclusion, and rejection: behavioral consequences related to fortifying relational needs (belonging, self-esteem, shared understanding and trust and attempts to fortify efficacy needs of control and recognition leading in antisocial thoughts and behavior (Williams, 2007). This model provided a base for the measuring scale further used in the empirical part of this thesis.

II. Empirical section

4. Research goal

The aim of the diploma thesis is to compare and specify the emotional reactions of patients with borderline personality disorder and the healthy population to virtual reality exposure scenarios that depict socially stressful situations from everyday life. This would help to evaluate the potential ecological validity of experimental scenarios within virtual reality. This research aim is part of a research project supported by the project of the Charles University Internal Agency, grant no. 1454120 and conducted in the Virtual Reality Laboratory at the National Institute of Mental Health (NIMH) in Klecany, Czech Republic. The author of the experimental scenarios is psychologist and researcher Mgr. Anna Francová.

As outlined in the theoretical section, patients with HPO are inclined to exhibit stronger emotional reactions to social stress and feelings of social exclusion. Even neutral cues within a social context are likely to elicit negative responses, potentially more intense than those observed in healthy controls. Therefore, this study focuses on the daily situations in virtual reality that possibly trigger social stress and intense emotional reactions. We expect that BPD patients' emotional responses will be more intense considering interpersonal stress and the need for belonging. Regarding the ecological validity in VR, ecological validity is viewed as a subcase of external validity, ideally, the evidence of high ecological validity would be a comparison of the observations in VR and observations in the real world (Parsons, 2015). (Bell et al., 2020) attribute the main factor to ecological validity to the level of immersion, the resulting feeling of presence, and overall technical design imitating the real world.

5. Research question and hypothesis

RQ: How do the emotional reactions of patients with borderline personality disorder differ from those of the healthy population when exposed to virtual reality scenarios depicting socially stressful situations from everyday life?

Based on the research question, several alternative hypotheses H1–H4 were stated and will be tested on Interpersonal Stress Coping Scale (ISCS) and Need Threat Scale (NTS; using subscale Need for belonging). Both of these questionnaires were administered in-between sessions. When stating these hypotheses we have to take into account both questionnaire scores in both scenarios in both modalities (negative and neutral).

Additionally, hypothesis H5 addressing the comparison of reactions (both also measured by ISCS and NTS) in the subpopulation of BPD patients group, which is negative vs. neutral scenarios were added.

H1a: BPD patients will demonstrate higher levels of negative *coping skills of interpersonal stress* (ISCS) than the control group after the *negative* scenario of the *bank*.

H1b: There is a significant difference in the *need for belonging* (NTS) in patients with BPD and the control group after the *negative* scenario of the *bank*.

H2a: There is a significant difference in the level of *coping with interpersonal stress* (ISCS) in patients with BPD and the control group after the *negative* scenario of the *train*.

H2b: BPD patients will demonstrate higher levels of negative *coping skills of interpersonal stress* (ISCS) than the control group after the *negative* scenario of the *train*.

H3a: BPD patients will demonstrate higher levels of negative *coping skills of interpersonal stress* (ISCS) than the control group after the *neutral* scenario of the *bank*.

H3b: There is a significant difference in the *need for belonging* (NTS) in patients with BPD and the control group after the *neutral* scenario of the *bank*.

H4a: BPD patients will demonstrate a higher level of *negative coping skills of interpersonal stress* (ISCS) than the control group after the *neutral* scenario of the *train*.

H4b: There is a significant difference in the *need for belonging* (NTS) in patients with BPD and the control group after the *neutral* of the *train*.

H5: There is a significant difference in *need for belonging* (NTS) and *negative skills of interpersonal stress* between *negative* and *neutral* scenarios in the experimental group of BPD patients.

6. Ethics

Participants in this study were fully informed about the research objectives, procedures, potential risks, and benefits before consenting to participate in the informed consent. Participants underwent a single session where they practiced controlling the VR application and completed specific tasks in a virtual environment simulating complex social situations. The session lasted no more than 75 minutes. All data collected were treated confidentially, with participants identified only by a code known to the research team. Participants were informed of their right to withdraw from the study at any time without consequence. The study was approved by the Ethics Committee of the National Institute of Mental Health. All participants signed a printed consent form and got a copy.

7. Sample

Data was collected from 42 participants as the aim was to reach 20 participants both in the control group and experimental. The power analysis conducted using G*Power indicated that, with a total sample size of 36 participants, an effect size of $f = 0.25$, and an alpha level of 0.05, the achieved power for the ANOVA repeated measures within-between interaction was 0.95. This high power level (95.18%) suggests a strong likelihood of detecting a true effect, thereby confirming that the sample size is adequate for the study (Faul et al., 2007).

The collected sample $N = 42$ consisted of 9 men and 33 women. One of them had to be excluded due to a failed administration. The final sample is $N = 41$. In total, the control group (healthy participants) included $n = 21$ participants, 15 women, and 6 men, aged 18–42 years ($M = 25.6$, $SD = 6.7$). Regarding education level, 19% indicated Elementary level ($n = 4$), 38% High School Diploma ($n = 8$), 9.5% Bachelor's Degree ($n = 2$), and 33% Master's Degree ($n = 7$). In the control group, 42.9% ($n = 9$) of participants were employed, 14.3% ($n = 3$) were both employed and students, 33.3% ($n = 7$) were students, and 4.8% ($n = 1$) were unemployed. None of the participants in the control group were on disability pension.

The experimental group (BPD patients) included $n = 20$ participants, 17 women, and 3 men, the mean age was 28.6 years. Regarding education, 20% indicated Elementary level ($n = 4$), 15% Bachelor Degree ($n = 3$), 45% High School Diploma ($n = 9$), 10% Higher Professional Education (DiS.) ($n = 2$), 10% Master Degree ($n = 2$). In the experimental group, 50.0% ($n = 10$) of participants were employed, 30.0% ($n = 6$) were on a disability pension, 15.0% ($n = 3$)

were students, and 5.0% ($n = 1$) were unemployed. None of the participants in the experimental group were both employed and students.

Both groups have a similar gender distribution. The control group consists of 71.4% women and 28.6% men, whereas the experimental group has 85% women and 15% men. Also, both groups have a very similar percentage of participants with an elementary-level education. The control group has 19% ($n = 4$), and the experimental group has 20% ($n = 4$). The biggest differences can be recognized in the employment status regarding Disability pension. This category shows the most significant difference between the groups. In the experimental group, 30% ($n = 6$) of participants were on disability pension, whereas none of the participants in the control group were on disability pension. There is also a notable difference in the percentage of students. In the control group, 33.3% ($n = 7$) of participants were students, while only 15% ($n = 3$) of the experimental group were students. Another notable difference is that 14.3% ($n = 3$) of participants in the control group were both employed and students, compared to none in the experimental group. See *Table 1* for the overview.

Table 1: Demographic information of participants (N=41)

Group	Control (n = 21)	Experimental (n = 20)
Gender		
Men	6 (28.6%)	3 (15%)
Women	15 (71.4%)	17 (85%)
Age (years)		
Mean (M)	25.6	28.6
Standard Deviation (SD)	6.7	8.53
Education Level		
Elementary	4 (19%)	4 (20%)
High School Diploma	8 (38%)	9 (45%)
Bachelor's Degree	2 (9.5%)	3 (15%)
Higher Professional Education	0	2 (10%)
Master's Degree	7 (33%)	2 (10%)
Employment Status		
Employed	9 (42.0%)	10 (50%)
Employed + Student	3 (14.3%)	0
On disability pension	0	6 (30%)
Student	7 (33.3%)	3 (15%)
Unemployed	1 (5%)	1 (5%)

8. Experimental scenarios

Presented experimental scenarios were created in the NIMH by the team of Laboratory of Virtual Reality (supported by the project of the Charles University Internal Agency, grant no. 1454120), the content of scenarios was consulted with a psychologist with schema therapy training. Virtual scenarios were made in order to trigger social cues leading to feelings like abandonment and ignorance.

The experiment comprised two scenarios, each presented in two variations: neutral and negative. Each scenario lasted 3 to 5 minutes and was standardized. The order of various scenarios was randomized in each participant. Consequently, participants were exposed to four distinct virtual situations:

- **Train (neutral):** This scenario took place in a train compartment. Participants were seated by the window, awaiting the train's departure from the station. During this waiting period, other individuals (avatars) entered the compartment and found seats. In the neutral condition, an avatar came into the compartment, looked around, approached the participant and sat directly beside them. Following this, the train departed, and the scenario concluded.
- **Train (negative):** This scenario took place in a train compartment. Participants were seated by the window, awaiting the train's departure from the station. During this waiting period, other individuals entered the compartment and found seats. In the negative condition, an avatar approached the participant and sat directly beside them, but after a short while stood up and relocated to another seat. These social cues might trigger feelings of rejection and abandonment (See *Figure 2* for the illustration).

Figure 2: Illustration of the virtual environment in the train



- **Bank (neutral):** This scenario took place in a bank lobby where participants were waiting for their turn according to an ordered list. Participants sat in the lobby and watched a display announcing the numbers of those called to proceed to the counter. In the neutral condition, when the participants' number was announced, they proceeded to the bank counter and then left the bank.
- **Bank (negative):** This scenario took place in a bank lobby where the participant was waiting for their turn according to an ordered list. The participant sat in the lobby and watched a display announcing the numbers of those called to proceed to the counter. In the negative condition, when the participant's number was announced, another avatar cut the line and acted angrily at the counter. Consequently, the participant was forced to wait longer to reach the counter. This social cue might trigger feelings of ignorance and negative effects like anger etc. See *Figure 3* for the illustration.

Figure 3: Illustration of the virtual environment in the bank lobby



9. Measuring tools

The test battery *before the session* includes the following: demographic information, Borderline symptom list (BSL-23), Perth Emotional Reactivity Scale (PERS), and Subjective Units of Distress Scale (SUDS), ESM subscale. For overview of used methods see *Table 2*.

Demographic information includes basic questions regarding age, sex, highest education level, and type of employment status.

Borderline Symptom List (BSL-23) is a short version of the original Borderline Symptom List and is a 23-item self-rating questionnaire assessing the BPD symptomatology in adults. It is based on the DSM-V BPD diagnostic criteria together with empirical findings about self-criticism, trust issues, emotional vulnerability, and proneness to shame and has a single-factor structure. Participants can rate each item on a 5-point scale, from 0 (not at all) to 4 (very strong), results can be found by counting the average score of items, therefore the higher the score shows, the more impairment is manifested (Bohus et al., 2009; Kleindienst et al., 2020).

Perth Emotional Reactivity Scale (PERS) is a 30-item questionnaire measuring trait level of emotional reactivity. They are intended to evaluate the usual ease of activation, intensity, and duration of an individual's emotional responses, separately for positive and negative emotions. PERS consists of 6 subscales: Positive-activation, Positive-intensity, Positive-duration, Negative-activation, Negative-intensity, and Negative-duration. Each item consists of a statement that respondents rate on a 5-point Likert scale, from 1 (very unlike me) to 5 (very like me), based on how well they believe it represents their typical daily behavior. Higher scores indicate higher emotional reactivity (Preece et al., 2019).

Subjective Units of Distress Scale (SUDS), items Emotional States (ESM) is a short 6-item screening test. Participants assessed their current emotional states by indicating the extent to which they were experiencing anger, depressive feelings, anxiety, stress, happiness, and relaxation, using a rating scale from 0 (not at all) to 10 (very much), resulting score was indicated on the subscales Positive affect and Negative affect (Houben et al., 2018). In order to provide data measuring overall distress, scores of positive effects were reversed.

The test battery *in-between sessions* includes the following: Interpersonal Stress Coping Scale (ISCS) and subscale Need For Belonging (NFB).

Interpersonal Stress Coping Scale (ISCS) assesses strategies used to cope with interpersonal stressors. It has 3 factors: Distancing (strategies aimed at actively damaging, disrupting, or ending a stressful relationship), Reassessing (coping refers to the approach of patiently waiting for the right moment to act), and Constructive coping (efforts to actively improve, maintain, or sustain a relationship without causing further conflict or distress to the other parties involved) in total of 15 items. Participants can assess tested strategies on a 4-level scale of 0 (Did not use) to 3 (Used a great deal) (Kato, 2013) In this research, the counted score refers to overall negative strategies of interpersonal coping as items in the third factor Constructive coping were reversed.

The Need Threat Scale (NTS), subscale Need For Belonging (NFB) was used to measure the need to have pleasant interactions with others and maintain relationships. Other subscales in the NTS are called Need for self-esteem and Control and meaningful existence. The NTS has 12 items, the subscale NFB includes 5 items. This scale was created by Williams (2007) and is based on the ostracism model. Participants can score on a scale ranging from 0 (Not at all) to 5 (Extremely).

The test battery *after the session* includes the following: Subjective Units of Distress Scale (SUDS; described above), The Simulator Sickness Questionnaire (SSQ), Igroup Presence Questionnaire (IPQ).

The Simulator Sickness Questionnaire (SSQ) was used to measure the severity of cybersickness symptoms experienced by users of virtual reality systems. It has 16 items and each item on the SSQ is rated on a 4-point scale from 0 (none)–3 (severe). The following criteria are therefore assessed: Nausea-related subscore (N), Oculomotor-related subscore (O), Disorientation-related subscore (D), and the Total Score (TS). The total score counted by sum of scores presents the overall severity of cybersickness experienced (Witmer & Singer, 1998).

Igroup Presence Questionnaire (IPQ) is a widely recognized tool designed to measure the sense of presence experienced in virtual environments (VE). Developed by Schubert, Friedmann, and Regenbrecht, the IPQ is composed of multiple items aimed at capturing different dimensions of presence. These include Spatial Presence, Involvement, and Experienced Realism, each addressing various aspects of the user's immersive experience in

virtual reality. It is a 14 items-scale ranging from 0 (Not at all) to 6 (Completely) (Schubert et al., 2001).

Table 2: Overview of measuring tools

Method	What it assesses	When it was used
Before the session		
Borderline Symptom List (BSL-23)	BPD symptomatology	Before the session
Perth Emotional Reactivity Scale (PERS)	Trait level of emotional reactivity	Before the session
Subjective Units of Distress Scale (SUDS) - Emotional States (ESM)	Current emotional states	Before the session
In-between scenarios		
Interpersonal Stress Coping Scale (ISCS)	Negative strategies used to cope with interpersonal stressors	In between scenarios
The Need Threat Scale (NTS) - Need For Belonging (NFB)	Need to have pleasant interactions with others	In between scenarios
After the session		
Subjective Units of Distress Scale (SUDS) - Emotional States (ESM)	Current emotional states	After the session
Simulator Sickness Questionnaire (SSQ)	Severity of cybersickness symptoms	After the session
Igroup Presence Questionnaire (IPQ)	Sense of presence	After the session

After the session, a few debriefing questions were asked to ensure participants had a smooth experience and to get additional information about their insights. These data aim to get feedback about the realism of virtual scenarios.

10. Procedure

The experimental study was conducted in the Laboratory of Virtual Reality at NIMH. This laboratory was equipped with a VR headset and controllers HTC VIVE Pro, staves, and a personal computer. All the questionnaires and instructions were held in the Czech language.

Data was collected in the period of 1. 11. 2023–31. 3. 2023. Participants were invited individually for 75-minute slots and underwent the experiment under the administration of the author of this thesis. Both the control and experimental groups were recruited through self-selection sampling via social media, with participation being voluntary and without compensation. However, control group participants received confirmation of their involvement for academic purposes. The social media ads provided additional detail about contraindications, time requirements, and a brief explanation of the aim of the study, noting that by participating they will support virtual reality research in mental health. Potential applicants were requested to apply by sending an email to the administrator. If they met the conditions (they do not have a neurological disease, they are 18–64 years old, and they do not suffer from a serious mental disorder of the schizophrenic type), they were promptly replied to and suggested a time slot for participation.

The experiment was divided into several parts. Firstly, participants were informed about the conditions of their participation, closely described in the informed consent which they signed. Followingly, the administrator read the instructions. The process of administration was the following: filling in the 'before' test battery, testing trial entrance of the neutral virtual reality environment to calibrate one's experience, undergoing 4 testing scenarios in virtual reality + in-between filling in the test battery, and final filling in the 'after-session' test battery.

During exposure to virtual reality, participants wore a headset and held controllers in their hands. The headset provided a 360° visual experience and included sound effects, simulating real-life scenarios through auditory perception. Their task was to watch the virtual situation and pay attention to the behavior of virtual avatars and the overall virtual situation: what they are doing, and how it affects the experience of the participants.

10.1 Statistical analysis

Data analysis and visualizations were conducted using Jamovi and R, with all analyses performed at a significance level of $\alpha = 0.05$.

Descriptive statistics and basic analyses for the control and experimental groups were provided using the Borderline Symptom List (BSL-23), the Perth Emotional Reactivity Scale (PERS), the Subjective Units of Distress Scale (SUDS), and items from the Emotional States (ESM) questionnaire. Additionally, descriptive statistics from the IPQ and SSQ questionnaires were included to evaluate the conditions of experiencing virtual reality.

Although normality testing below showed normal distribution in most of the data, due to a rather small sample we used non-parametric tests, specifically the Mann-Whitney U test. Normality was assessed through data visualization and tested by the Shapiro-Wilk test. To test hypotheses regarding differences between groups, data from the Interpersonal Coping Stress Scale (ISCS) and the Need Threat Scale (NTS), particularly the Need for Belonging (NFB) subscale, were utilized, with these measures administered after each scenario. For within-group comparisons of emotional reactivity (NTS) and ISCS levels in the experimental and control groups, the Wilcoxon signed-rank test was applied.

10.2 Results

10.2.1 Borderline Symptom List (BSL-23)

The mean BSL-23 score of the control group ($n = 21$) was 12.7 ($SD = 10.0$; $Mdn = 10$). Scores ranged from 1 to 43. The Shapiro-Wilk test indicated that the distribution of scores significantly deviated from normality, $W(21) = 0.851$, $p = 0.004$. In comparison, for the experimental group ($n = 20$) the mean BSL-23 score was 40.0 ($SD = 21.0$; $Mdn = 40.5$). Scores ranged from 1 to 82. The Shapiro-Wilk test indicated that the distribution of scores did not significantly deviate from normality, $W(20) = 0.981$, $p = 0.945$.

Table 3: Overview of descriptives of BSL-23

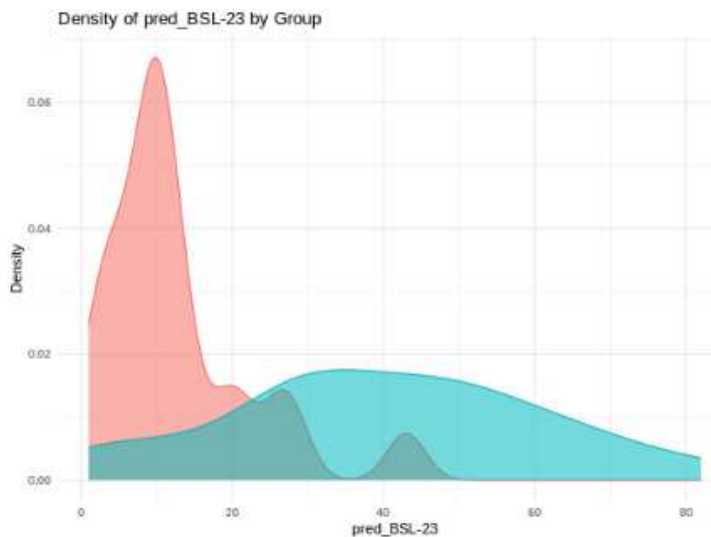
Group	M	Mdn	SD	Min	Max
Control	12.7	10	10.0	1	43
Experimental	40.0	40.5	21.0	1	82

Note: **M** = Mean; **Mdn** = Median, **SD** = Standard deviation, **Min** = Minimum, **Max** = Maximum

The Mann-Whitney U test was conducted to compare the BLS-23 scores, which measure borderline symptoms, between the control group (healthy controls) and the experimental group (BPD patients). The Shapiro-Wilk test indicated that the control group's scores were normally distributed ($W = 0.959, p = 0.494$), while the experimental group's scores were not ($W = 0.872, p = 0.013$). Given the non-normal distribution of the experimental group's data, the Mann-Whitney U test was considered more appropriate. The Mann-Whitney U test revealed a significant difference in BLS-23 scores between the control and experimental groups, $U = 53.5, p < .001$, with a mean difference of -27.0 . The effect size, measured by rank biserial correlation, was 0.745 , indicating a large effect size.

In summary, it indicates a significant difference in BLS-23 scores between the control group and the experimental group. Specifically, the BPD patients (experimental group) scored significantly higher on the BLS-23, indicating more severe borderline symptoms compared to the healthy controls (control group).

Figure 4: Density plot of borderline symptomatology (BSL-23) in control (C) and experimental group (E)



10.2.2 Perth Emotional Reactivity Scale (PERS)

For the control group, the mean PERS score was 96.3 ($SD = 12.5$; $Mdn = 95$). Scores ranged from 68 to 117. The Shapiro-Wilk test indicated that the distribution of scores did not significantly deviate from normality, $W(21) = 0.969$, $p = 0.708$. For the experimental group ($n = 20$) score was 112 ($SD = 16.1$; $Mdn = 115$). Scores ranged from 79 to 133. The Shapiro-Wilk test indicated that the distribution of scores significantly deviated from normality, $W(20) = 0.883$, $p = 0.020$.

BPD patients (experimental group) exhibit higher mean and median PERS scores, reflecting higher emotional reactivity compared to healthy controls (control group). The greater variability in the experimental group's scores suggests more diverse emotional experiences among BPD patients. The control group's PERS scores are normally distributed, while the experimental group's scores deviate from normality, which may require the use of non-parametric tests or transformations in further analyses.

Table 4: Overview of descriptive statistics of PERS

Group	M	Mdn	SD	Min	Max
Control	96.3	95	12.5	68	117
Experimental	112.0	115	16.1	79	133

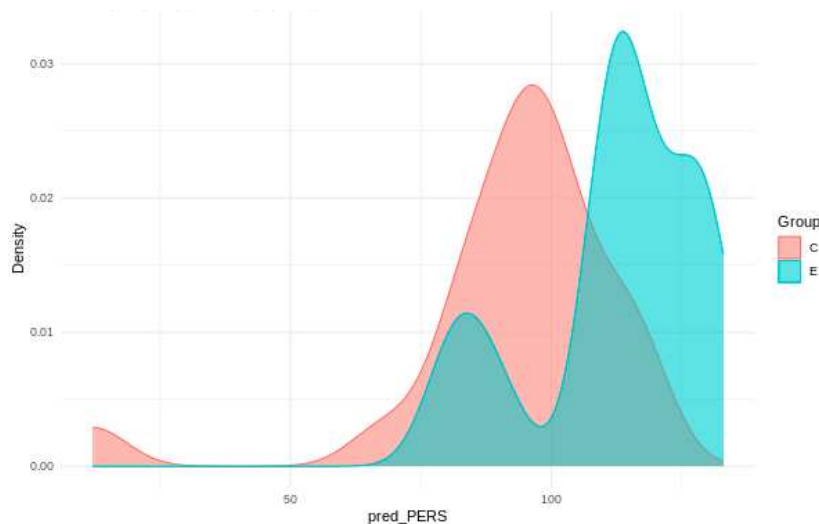
Note: **M** = Mean, **SD** = Standard deviation, **Min** = Minimum, **Max** = Maximum

The Shapiro-Wilk normality test results for the PERS scores indicate a significant deviation from normality ($W = 0.941$, $p = 0.034$). Given that the p-value is less than 0.05, it suggests a violation of the assumption of normality, therefore Mann-Whitney U test is considered more appropriate. The Mann-Whitney U test indicated a significant difference between the groups, $U = 95.0$, $p = 0.003$, with a mean difference of -18.0. The effect size, measured by rank biserial correlation, was 0.548, indicating a moderate to large effect size.

In conclusion, the Mann-Whitney U test indicates a significant difference in PERS scores between the control group and the experimental group. Specifically, the BPD patients

(experimental group) scored significantly higher on the PERS, indicating higher levels of emotional reactivity compared to the healthy controls (control group).

Figure 5: Density plot of emotional reactivity (PERS) in control and experimental group



10.2.3 Overall Distress (SUDS)

Regarding the control group, the mean pre-session distress score was $M = 16.0$ ($SD = 7.48$). The median score was 16, with scores ranging from 4 to 38. The Shapiro-Wilk test indicated marginal non-normality, $W = 0.911$, $p = 0.058$. By the experimental group of BPD patients, the mean pre-session distress score was $M = 27.1$ ($SD = 13.0$). The median score was 26.5, with scores ranging from 6 to 51. The Shapiro-Wilk test indicated normality, $W = 0.951$, $p = 0.507$.

The mean post-session distress for the control group score was $M = 13.5$ ($SD = 6.64$). The median score was 11, with scores ranging from 2 to 27. The Shapiro-Wilk test indicated normality, $W = 0.947$, $p = 0.296$. For the experimental group, the mean post-session distress score was $M = 23.8$ ($SD = 7.68$). The median score was 22.0, with scores ranging from 13 to 42. The Shapiro-Wilk test indicated normality, $W = 0.931$, $p = 0.162$.

For pre-session distress levels (pred_SUDS), the Mann-Whitney U test indicated a significant difference between the control group ($Mdn = 16$) and the experimental group ($Mdn = 26.5$), $U = 97.5$, $p = 0.003$, with a rank biserial correlation effect size of 0.536.

For post-session distress levels (po_SUDS), the Mann-Whitney U test also indicated a significant difference between the control group ($Mdn = 11$) and the experimental group ($Mdn = 22$), $U = 63.5$, $p < 0.001$, with a rank biserial correlation effect size of 0.698.

These results suggest that the experimental group experienced higher distress levels both before and after the session, with a more pronounced difference observed post-session. This could imply that the intervention or conditions in the experimental setup had a significant impact on the participants' distress levels.

10.2.4 Sickness Simulator Questionnaire (SSQ)

The experimental group reported higher mean nausea scores ($M = 2.90$) compared to the control group ($M = 1.71$), also oculomotor disturbance scores ($M = 4.45$) compared to the control group ($M = 3.90$). Interestingly, the control group reported higher mean disorientation scores ($M = 2.52$) compared to the experimental group ($M = 1.85$). See Table 5 for the overview. The overall post-session SSQ scores were higher in the experimental group ($M = 8.15$) compared to the control group ($M = 7.00$). To sum it up, results suggest that the experimental group experienced more nausea and oculomotor disturbances but less disorientation compared to the control group. The overall simulator sickness scores were also higher in the experimental group, indicating a greater level of discomfort or sickness after the session.

Table 5: Descriptive statistics of raw scores of SSQ

Group	Factor	Mean	Median	SD	Sum	Min	Max
C	SSQ	7.00	7.00	4	147	1	16
E	SSQ	8.15	5.50	5.06	163	12	17
C	F1 Nausea	1.71	1.00	1.74	36	0	7
E	F1 Nausea	2.90	2.00	2.51	58	0	8
C	F2 Oculomotor	3.90	4.00	2.05	82	0	8
E	F2 Oculomotor	4.45	3.00	3.00	89	1	10
C	F1 Disorientation	2.52	3.00	1.75	53	0	5
E	F1 Disorientation	1.85	1.50	1.63	37	0	6

Note: C = control group, E = experimental group, **Sum** = suma, **Min** = minimum, **Max**= maximum

Stanney et al. (1997) recommend interpreting result scoring: <5 points = negligible symptoms, 5-10 points = minimal symptoms, 10-15 points = significant symptoms, 15-20 points = worrying symptoms, and a score exceeding 20 points would indicate a bad test. Control group scored in the minimal symptoms range ($M = 7$) and the experimental group scored also in the minimal symptoms range ($M = 8.15$).

10.2.5 Igroup Presence Questionnaire (IPQ)

The average raw scores of IPQ which reflect the overall immersion and presence in the virtual environment, showed the following descriptive statistics: Control Group (C): $M = 3.37$ ($SD = 0.70$; $Mdn = 3.40$; $Min = 2$; $Max = 4$) and Experimental Group (E): $M = 2.98$ ($SD = 0.88$; $Mdn = 3.00$; $Min = 1$; $Max = 4$). Further description of average scoring (M) and standard deviations (SD) in each factor is provided in *Table 6*. These results indicate that the control group had a relatively higher and more consistent po_IPQ scores, while the experimental group had more variability in their scores, with a broader range and slightly lower central tendency.

Table 6: Descriptive statistics of the average raw scores of general IPQ

Factor	Group	Mean	Sum	Median	SD	Min	Max
Overall score	C	3.37	70.8	3.40	0.70	2.26	4.75
	E	2.98	59.6	3.00	0.88	1.79	4.81
General	C	3.43	72	4	1.36	1	6
	E	3.20	64	3.50	1.70	0	6
Presence	C	4.24	89	3.40	0.70	3	6
	E	3.55	71	3.00	0.88	3	6
Immersion	C	3.24	68	3.40	0.70	2	4
	E	2.80	56	3.00	0.88	1	4
Realism	C	2.76	58	3	0.63	1	4
	E	2.60	52	2.50	0.68	2	4

Note: C = control group, E = experimental group, **Sum** = suma, **SD** = standard deviation, **Min** = minimum, **Max** = maximum

10.2.6 Hypothesis testing: Interpersonal coping stress (ISCS) and Need of Belonging (NDB)

Firstly, descriptive statistics is assessed and presented in *Table 7*. Afterwards, type of distribution is evaluated and also presented in *Table 8*.

Table 7: Descriptive statistics of scores of experimental and control groups in all scenarios and questionnaires ICSC and NTS

Group	Scenario_questionnaire	Mean	Median	SD	Sum	Min	Max
C	TrainNeutral_ICSC*	25.6	25	6.12	537	14	40
E	TrainNegative_ICSC*	23.9	24.5	5.61	477	15	35
C	TrainNeutral_NTS	18.0	18	2.53	378	13	23
E	TrainNeutral_NTS	15.8	16.5	3.65	315	7	22
C	TrainNegative_ICSC*	25.5	25	6.99	535	10	36
E	TrainNegative_ICSC*	23.6	25.5	5.85	473	12	31
C	TrainNegative_NTS	15.5	15	3.36	326	4	23
E	TrainNegative_NTS	12.3	12.5	2.76	247	8	18
C	BankNeutral_ICSC*	24.0	23	6.69	503	14	42
E	BankNeutral_ICSC*	21.2	21.5	7.18	424	6	42
C	BankNeutral_NTS	18.3	15.5	2.39	385	12	35
E	BankNeutral_NTS	15.3	15.5	2.89	306	8	40
C	BankNegative_ICSC*	26.2	21	6.50	551	14	40
E	BankNegative_ICSC*	21.6	21	6.89	432	8	41
C	BankNegative_NTS	16.9	15.5	3.63	355	9	19
E	BankNegative_NTS	14.6	15.5	3.32	291	8	19

Note: C = control group, E = experimental group, ICSC = Interpersonal Stress Coping Scale, NTS = subscale Need for belonging, **Sum** = suma, **SD** = standard deviation, **Min** = minimum, **Max** = maximum; *= when testing scores on ICSC, the one-sided hypothesis was applied.

The Shapiro-Wilk test was conducted to assess the normality of the distributions for various variables across control (C) and experimental (E) groups. The table shows the W statistic and p-value for each variable:

Table 8: Overview of normality testing of ISCS and NTS

Group	Scenario_questionnaire	W	p value	Distribution
C	TrainNeutral_ISCS	0.983	0.966	Normal
E	TrainNeutral_ISCS	0.983	0.966	Normal
C	TrainNeutral_NTS	0.981	0.936	Normal
E	TrainNeutral_NTS	0.914	0.0657	Normal
C	TrainNegative_ISCS	0.951	0.356	Normal
E	TrainNegative_ISCS	0.894	0.0314	Not Normal
C	TrainNegative_NTS	0.914	0.0657	Normal
E	TrainNegative_NTS	0.966	0.677	Normal
C	BankNeutral_ISCS	0.900	0.0357	Not Normal
E	BankNeutral_ISCS	0.980	0.396	Normal
C	BankNeutral_NTS	0.932	0.152	Normal
E	BankNeutral_NTS	0.831	0.00258	Not Normal
C	BankNegative_ISCS	0.955	0.423	Normal
E	BankNegative_ISCS	0.981	0.948	Normal
C	BankNegative_NTS	0.846	0.00362	Not Normal
E	BankNegative_NTS	0.922	0.110	Normal

Note: C = control group, E = experimental group

The variables BankNeutral_ISCS, BankNegative_NTS in the control group, and TtrainNegative_ISCS, BankNeutral_NTS in the experimental group do not follow a normal distribution. For the other variables, the normality assumption holds. However, for more robust results, non-parametric tests were used. The distribution in density plots is shown below in Figure 6 and Figure 7.

Figure 6: Kernel density plot of train scenarios in both modalities of both groups in train scenarios

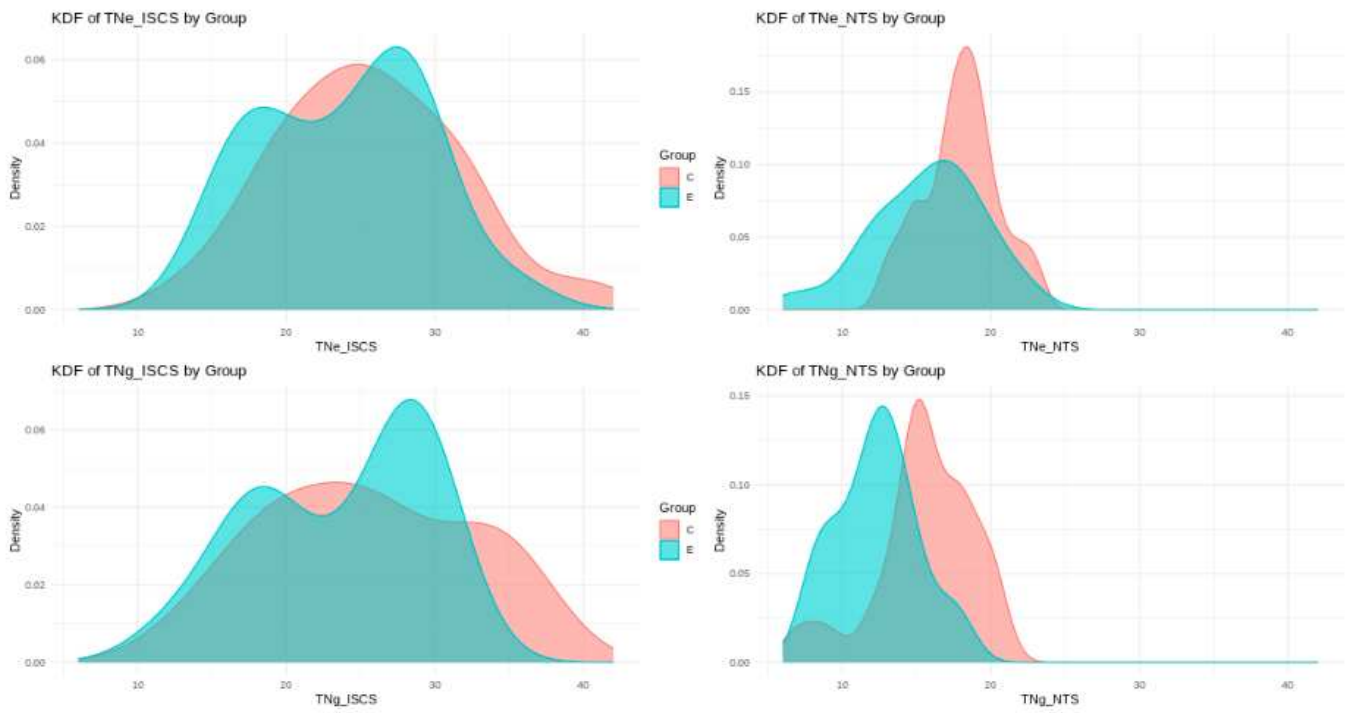
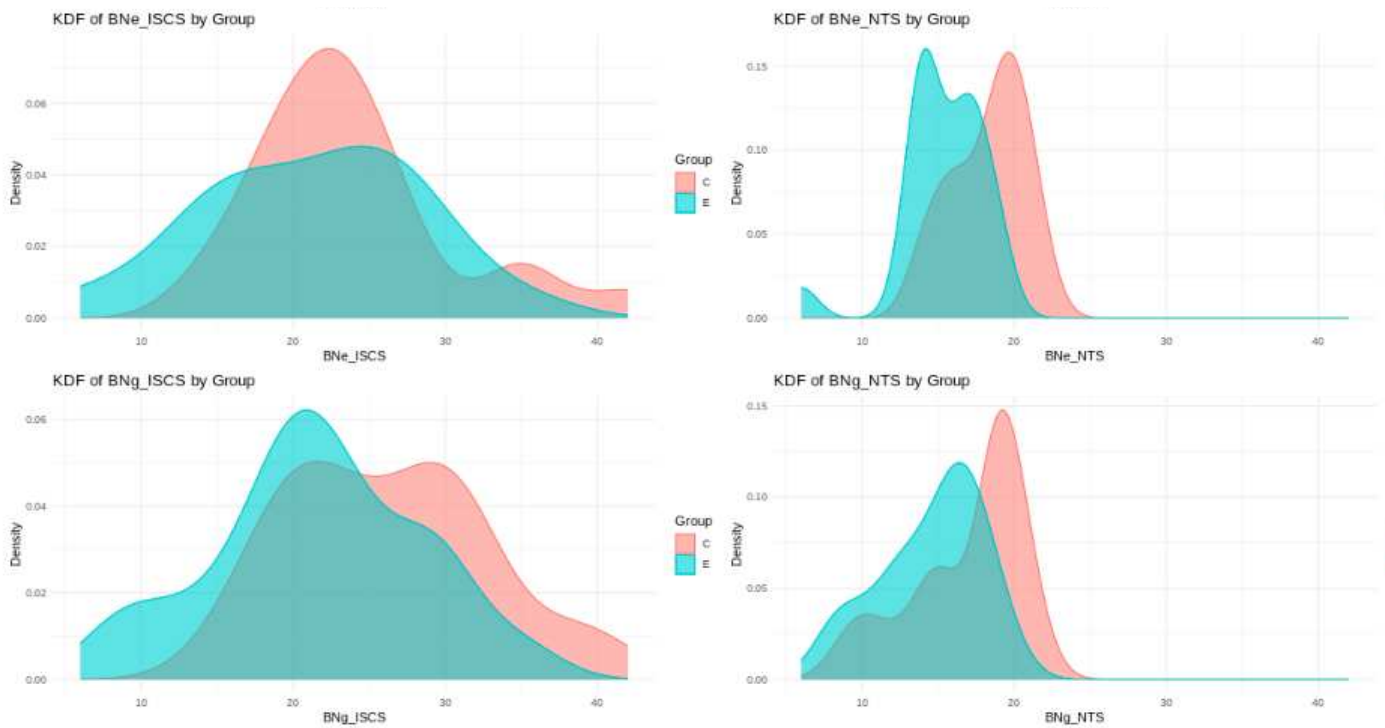


Figure 7: Kernel density plot of bank scenarios of both groups in bank scenarios



Negative bank scenario

H1a: BPD patients will demonstrate higher level of negative coping skills of interpersonal stress (ISCS) than the control group after the negative scenario of the bank.

Based on the Mann-Whitney U test, the results indicated that there was no statistically significant difference between the two groups, $W = 134$, $p = 0.9772$. The effect size was -0.004 , suggesting a negligible difference in ISCS scores between the groups. These results suggest that both the experimental and control groups exhibit similar levels of negative interpersonal coping in the negative bank scenario.

H1b: There is a significant difference in the need for belonging (NTS) in patients with BPD and the control group after the negative scenario of the bank.

Based on the Mann-Whitney U test results, there is a statistically significant difference in the Need for Belonging between the control group and the experimental group in the bank negative scenario ($W = 300$, $p = 0.018$). The effect size was -0.368 . This suggests that the need for belonging scores are significantly different across both groups in this scenario, with the control group experiencing a higher level of need of belonging compared to the experimental.

Negative train scenario

H2a: BPD patients will demonstrate a higher level of negative coping skills of interpersonal stress (ISCS) than the control group after the negative scenario of the train.

Based on the Mann-Whitney U test, the results indicated that there was no statistically significant difference between the two groups, $W = 182.5$, $p = 0.768$. The effect size was -0.046 , suggesting a negligible difference in ISCS scores between the groups.

H2b: There is a significant difference in the need for belonging (NTS) in patients with BPD and the control group after the negative scenario of the train.

Based on the Mann-Whitney U test results, there is a statistically significant difference in the Need for Belonging between the control group and the experimental group in the negative scenario ($W = 333$, $p = 0.001$). The effect size was -0.502 . This suggests that the need

for belonging scores are significantly different across both groups in this scenario, with the control group experiencing a higher level of need compared to the experimental.

Neutral bank scenario

H3a: BPD patients will demonstrate a higher level of negative coping skills of interpersonal stress (ISCS) than the control group after the neutral scenario of the bank.

Based on the Mann-Whitney U test results, there is no statistically significant difference in Negative Interpersonal Coping between the control group and the experimental group in the bank neutral scenario ($W = 176.5, p = 0.813$). The effect size was $r = -0.036$. This suggests that the negative interpersonal coping scores are similar across both groups in this scenario.

H3b: There is a significant difference in the need for belonging (NTS) in patients with BPD and the control group after the neutral scenario of the bank.

Based on the Mann-Whitney U test results, there is a statistically significant difference in the Need for Belonging between the control group and the experimental group in the bank neutral scenario ($W = 337.5, p = 0.001$). The effect size was $r = -0.522$. This suggests that the need for belonging scores are significantly different across both groups in this scenario while the control group of healthy controls scores higher.

Neutral train scenario

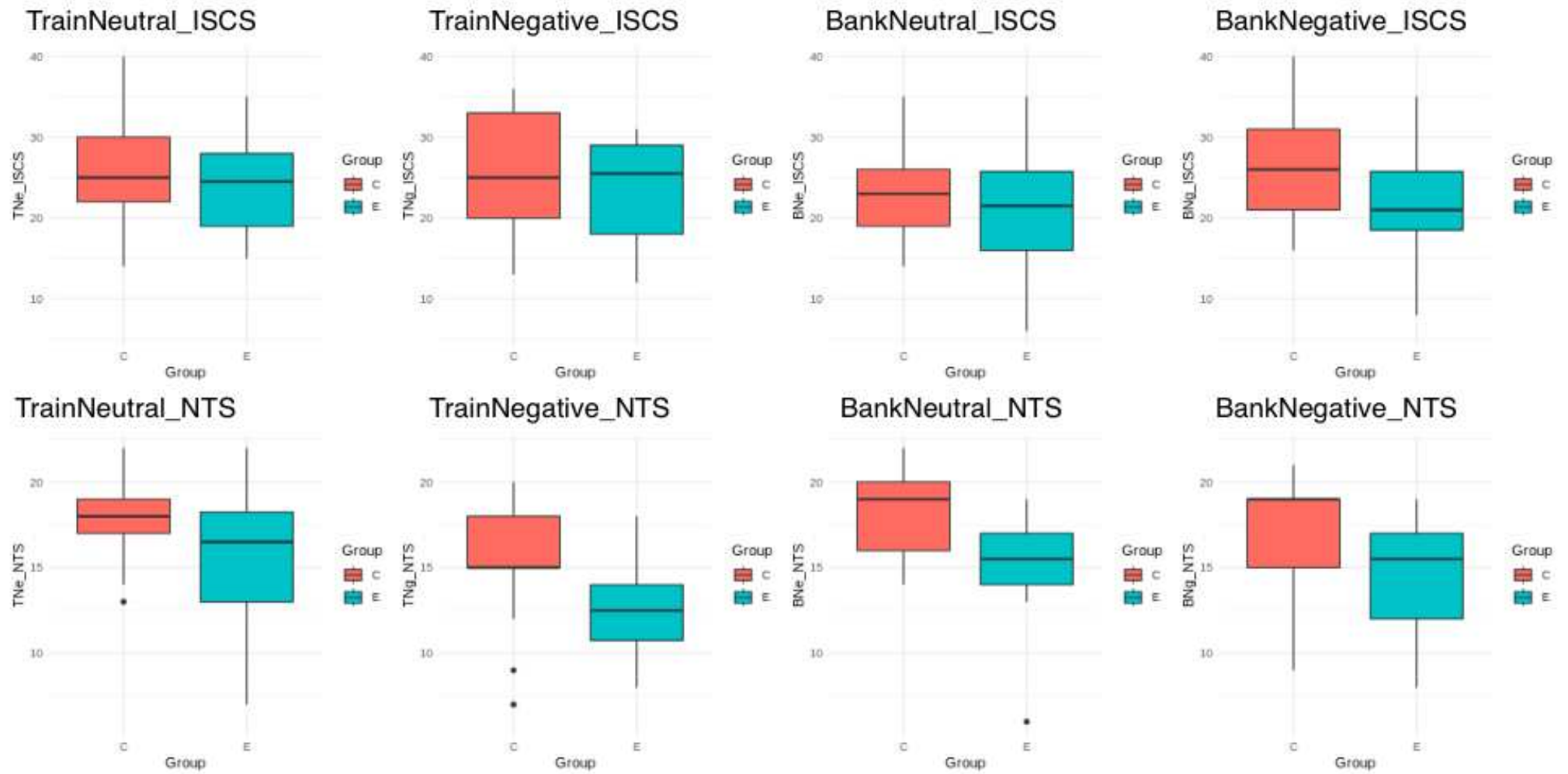
H4a: BPD patients will demonstrate higher level of negative coping skills of interpersonal stress (ISCS) than the control group after the neutral scenario of the train.

Based on the Mann-Whitney U test the results indicated that there was no statistically significant difference between the two groups, $W = 182.5, p = 0.768$. The effect size was -0.046 . These results suggest that both the experimental and control groups exhibit similar levels of negative interpersonal coping in the negative train scenario.

H4b: There is a significant difference in the need for belonging (NTS) in patients with BPD and the control group after the neutral of the train.

Based on the Mann-Whitney U test results, there is a statistically significant difference in the Need for Belonging between the control group and the experimental group in the train neutral scenario ($W = 289.5$, $p = 0.04$). The effect size was -0.324 . This suggests that the need for belonging scores are significantly different across both groups in this scenario while control group scores are higher.

Figure 8: Boxplot demonstrating results of experimental and control group in bank/train scenarios in both modalities



H5: There is a significant difference in the need for belonging (NTS) and negative skills of interpersonal stress (ISCS) between negative and neutral scenarios in the experimental group of BPD patients.

Comparison of reactions in both train scenarios in BPD patients

Based on the Wilcoxon signed-rank test results, there is no statistically significant difference in negative interpersonal coping (ISCS) between the neutral (TNe) and negative (TNg) scenarios within the experimental group of BPD patients ($V = 70.5$, $p = 0.9175$). The effect size is $r = -0.023$. This suggests that the coping scores are similar across both scenarios.

Based on the Wilcoxon signed-rank test results, there is a statistically significant difference in the Need for Belonging (NTS) scores between the train neutral (TNe_NTS) and train negative (TNg_NTS) scenarios within the experimental group of BPD patients ($V = 152.5$, $p = 0.004$). The effect size is $r = -0.648$. This suggests that the need for belonging scores are significantly higher across the neutral train scenario in BPD patients (See *Figure 8* for the comparison).

Comparison of reactions in both bank scenarios in BPD patients

Based on the Wilcoxon signed-rank test results, there is no statistically significant difference in Negative Interpersonal Coping (ISCS) between the bank neutral (BNe) and bank negative (BNg) scenarios within the experimental group of BPD patients ($V = 86.5$, $p = 0.9826$). The effect size is $r = -0.005$. This suggests that the coping scores are similar across both scenarios.

Based on the Wilcoxon signed-rank test results, there is no statistically significant difference in the Need for Belonging (NTS) between the bank neutral (BNe) and bank negative (BNg) scenarios within the experimental group of BPD patients ($V = 77$, $p = 0.3412$). The effect size is $r = -0.212$. This suggests that the need for belonging scores are similar across both scenarios.

Discussion

The aim of the presented diploma thesis is to compare and eventually specify the emotional reactions of patients with borderline personality disorder (BPD) and the healthy population to virtual reality exposure scenarios that depict socially stressful situations from everyday life. Specific social cues, such as social exclusion, rejection, or ignorance determine the difficulty of these situations. The scenarios included common situations that are usually associated with increased reactivity in patients with BPD: the scenario in the train compartment where the virtual avatar comes to have a seat next to the participant but after a while decides to change the seat and the scenario in the bank lobby where participants await for their turn to the counter but some other virtual avatar cuts the line. Both of them also have the neutral modality where triggering stressors (cutting a lane, reseating the avatar) do not happen. The results of this research will help to verify the potential of the ecological validity of the mentioned virtual reality scenarios. Five main hypotheses were stated and associated statistical procedures were performed.

To conclude, stronger emotional reactions related to the need for belonging when feeling rejected are more specific to healthy controls. In contrast, patients with borderline personality disorder (BPD) are more likely to withdraw from the situation without attempting to integrate into the social context. The need for belonging was measured by the subscale Need for belonging of the Need Threat Scale (NTS). It is focused on experiences of social ostracism and individual reactions to perceived ostracism, specifically the need to have pleasant interactions with others.

When comparing reactions at the level of negative interpersonal coping, we did not find significant differences between groups, likely due to the Interpersonal Coping Stress Scale (ISCS). This scale measures coping styles when dealing with interpersonal stress.

The findings also suggest that there are no significant differences in negative coping among BPD patients when facing either negative or neutral situations. Regarding the need to maintain relationships and tendencies to belong in non-triggering situations, BPD patients exhibit noticeable reactions. The following paragraphs provide a further explanation.

Significant results supported the following hypothesis: H1b, H2b, H2b, H4b. All four hypotheses regarding the need for belonging (measured in NTS) are therefore included. This indicates significantly different levels of BPD patients and healthy controls in the Need of

belonging scale in both negative and neutral modalities of both scenarios (bank, train). Heightened sensitivity to social rejection and need for belonging in BPD patients would align with theories of emotional dysregulation and interpersonal hypersensitivity in BPD (Crowell et al., 2009; Chapman et al., 2015; Lazarus et al., 2014). However, the significant differences in the need for belonging, even in neutral scenarios, show that control groups of healthy participants have actually a higher level of need for belonging. The Need for Belonging subscale of the Need Threat Scale measures an individual's desire to form and maintain interpersonal connections. This subscale assesses the extent to which individuals feel the need to belong and be accepted by others, which is a fundamental human motivation. This is supported by Williams' (2009) model of ostracism, which posits that being ignored or excluded threatens four fundamental needs: belonging, self-esteem, control, and meaningful existence (Williams, 2009). According to this model, individuals who experience ostracism undergo a threat to their need for belonging, which can lead to increased efforts to regain social inclusion and connection. BPD patients, who are known to have heightened sensitivity to social rejection and exclusion, may exhibit a stronger reaction to these threats, manifesting as a heightened need for belonging. Moreover, BPD patients often face interpersonal difficulties due to a chronic fear of abandonment and a strong need for acceptance (De Panfilis et al., 2015).

Although theory would suggest results demonstrating higher scores of BPDs in the need for belonging, opposite scores were shown. We can find an explanation in the tendency of BPD patients to split. This idea is supported by the psychoanalytical view, mixing extreme tendencies of idealization with extreme tendencies of refusal of others (Fertuck et al., 2018). When dealing with a rejection, BPD participants might be giving up the situation and non-participating at all. According to Williams's model of ostracism, being ignored in the group can not only lead to proactive tendencies, but in the larger amount of feelings of exclusion, it can also support total resignation (Seidl et al., 2020; Williams, 2009). The experimental study by Liebke et al. (2018) also demonstrated that BPD patients have lower expectations of social acceptance and in the case of virtual rejection, they did not trigger any aggression reaction but also any cooperation. From this point of view, we can support that healthy controls scored higher than BPD patients, as they also showed lower borderline symptoms measured by BSL-23 suggesting lower tendencies of splitting and social rejections. Additionally, in the study of Houben et al. (2018), patients with BPD evaluated their current emotional states and experienced trust in themselves and others when facing challenging questions. When they faced disappointment and distrust in others, they demonstrated mainly

negative affects. Positive affects were observed only in the context of the situation, to which the participants attached significant importance.

Non-significant results are relevant for the following hypotheses: H1a, H2a, H3a, H4a. All hypotheses regarding ICSC are therefore included in both scenario modalities. The lack of significant differences in coping skills in scenarios may indicate that environments do not sufficiently challenge the maladaptive coping mechanisms in BPD patients, as they might not trigger the same level of emotional distress. The similarity in coping responses across groups in certain scenarios suggests that the impact of these scenarios might not be strong enough to differentiate between the coping strategies of BPD patients and healthy controls. According to the theory, the expected result would be that BPD patients in comparison to healthy controls would demonstrate negative coping skills, in the ISCS measured by items like: “Tried to avoid contact with the person” or “Took a pragmatic view of the matter”.

We need to consider the measurement tool as well. Items in the ISCS questionnaire refer to a generic “person”, not to our specific scenario situation, and this might be a possible explanation of why results do not connect to the theory. Another possible explanation might be that the ISCS may not be sufficiently sensitive to detect subtle differences in coping mechanisms specific to BPD. While the ISCS includes items related to distancing and reassessing, it may lack specificity in identifying maladaptive coping strategies like splitting, impulsivity, or intense emotional reactions commonly seen in BPD.

BPD is characterized by significant variability in social functioning and some individuals with BPD may have developed more effective coping mechanisms over time, particularly if they have engaged in treatments such as Dialectical Behavior Therapy (DBT). Also, the past experiences of participants when traveling on the train or when going to the bank might be relevant. From the debriefing questions, it stood out that some participants perceived other passengers neutrally like they might have been mistaken when finding their place, booked different seats, or wanted to sit by the window. This would imply they do not perceive situations as stressful and do not have to use coping mechanisms.

Considering H5 when comparing the reactions of BPD patients in both neutral and negative scenarios, we could have found if the reactions are significantly different towards triggering and non-triggering situations. The results suggest that BPD patients may exhibit a generally heightened and consistent level of emotional reactivity and maladaptive coping across various social scenarios, without significant differentiation between neutral and negative

contexts. The train scenario reactions measured by NFT were the only significant result indicating that BPD patients react on higher scores in *neutral* situations. Same as above, rejection demonstrated in the training scenario leads to a more passive approach in the social situation. In this train scenario, when a random passenger sits closely but then changes seats, BPD patients might experience intense feelings of rejection, triggering the Abandonment/Instability schema and the Vulnerable Child mode according to schematherapy theory by Young (2003). The Angry Child mode might also be activated, resulting in anger and frustration towards the perceived rejection. Such reactions align with their typical interpersonal hypersensitivity and fear of negative evaluation (Young, 2003). According to this, when missing rejection in the neutral scenario, a need for belonging might arise. For further consideration, it might be beneficial to take into account how patients relate to other persons and assess which external social situations are actually causing them stress. According to Pertaub et al. (2001), virtual avatars are capable of causing social stress in patients with social phobia, however, it is necessary to further examine the various characteristics of social relationality in BPD.

Furthermore, the significant differences in both PERS and BSL-23 scores between the control and experimental groups highlight the distinct psychological profiles of BPD patients compared to healthy controls. These scores suggest that BPD patients have higher baseline emotional reactivity and borderline traits, which is a core feature of BPD. This heightened reactivity can influence how they perceive and respond to social stressors in VR scenarios.

SUDS measured the overall distress before and after the whole experiment. Higher levels of distress at the beginning of the session might be caused by the laboratory conditions, trying new technology, and facing new experiences in general as well as a new encounter with the administrator. For the reduction of the stress from the virtual environment, before the testing scenario, participants could try the neutral virtual environment (the neutral scene where a participant is sitting on the bench in the park and was instructed to look around, and get used to the headset and controllers).

Due to the virtual environment, two questionnaires exploring VR experience were used. Results of the Simulator Sickness Questionnaire (SSQ) showed only a mild level of sickness. The most scored items were optical blur which might have been caused by the headset and its setting. What is more, Bouchard et al. (2017) demonstrated that eventual high scores in SSQ are connected with high levels of anxiety. To comment on the IPQ, the higher level of immersion likely enhanced healthy controls' emotional and coping responses, while the

variability and lower presence in the BPD group may have affected their engagement and subsequent reactions to the VR scenarios.

Regarding methodological consideration, a larger and more diverse sample might be used in further research to enhance the generalizability of the findings. A certain drawback of this study might be using self-reporting measures as participants might have fallen for social desirability bias. What is more, due to the rather large test battery, participants might have made mistakes out of attention issues. The challenge of this research also lies in the quick alternation of stimuli (scenarios) and their subsequent measurement. Generally, results indicate a challenging nature of studying social aspects in the laboratory environment.

Additionally, the collection of data when targeting BPD patients was shown to be challenging as almost 50% of sessions were canceled either without any advance notice or by last-minute apology from the side of participants. Being the administrator of the study (both in the control and experimental group) provided the author with valuable insights and opportunities to observe interesting phenomena. Furthermore, the author could ask participants additional questions. While observing BPD patients in virtual reality, some displayed behaviors beyond the observational instructions: they threw virtual pencils at other avatars, waved with virtual hands, gestured, or talked to them. When answering questions, some participants perceived negatively presented avatars, such as describing a lady coming to share a seat on the train as “looking dirty, angry, and poorly dressed”. Participants with BPD often assessed the facial expressions of avatars negatively, noting a lack of expressions which caused confusion. This goes in line with Domes et al. (2009) who studied BPD patients and their recognizing emotions, and found out BPDs have the tendency to interpret neutral social context negatively. They reported being unable to interpret what the avatars were thinking and assumed that the avatars disliked them. Regarding the negative train scenario, nearly all BPD participants described feelings of self-doubt, thinking they looked strange or smelled bad. As already mentioned, social desirability also played a role when assessing BPD patients. What is more, BPD individuals are known for their tendency of idealization in social relationships (Story et al., 2014). This phenomenon may also be connected with a brief relationship with the administrator during the experiment and therefore results in questionnaires might be biased.

To address future research direction, another measuring tool might be used, State Difficulties in Emotion Regulation Scale (DERS) (Lavender et al., 2017) to measure emotional dysregulation and or Coping Strategies Inventory Short Form (CSI-SF) (Addison et al., 2024) to assess how dealing with interpersonal stress, both in-between of scenarios. These might

provide a full view of the emotional reactivity of BPD patients. As it is already planned in the research project of NIMH, the results of BPD individuals will be compared not only to healthy controls but also to patients with social phobia. Regarding patients with BPD, it would be interesting to record the length of their treatment as well when assessing demographic information to consider therapeutic treatment within the amount of the emotional disturbance.

Conclusion

The presented thesis aimed to describe how daily social stressors in virtual reality impact the emotional experiences of individuals with BPD. By understanding how BPD patients reacted to these stressors, researchers could develop better research and therapeutic interventions tailored to their specific emotional and social challenges.

The study found that BPD patients exhibited significantly lower levels of need for belongingness compared to the control group when exposed to social scenarios in VR, the control group demonstrated higher levels of need of belonging (NTS). However, the expected higher levels of negative interpersonal coping (ISCS) in BPD patients were not consistently observed across different scenarios. What is more, when comparing results only in the BPD subgroup between negative and neutral virtual scenarios, the only significant difference was in the negative and neutral train scenarios considering the need for belonging.

These findings have important implications for future research. Additionally, the significant difference in the need for belongingness highlights the importance of addressing social inclusion in therapeutic interventions for BPD.

The use of VR in therapy could provide a safe and controlled environment to help BPD patients develop healthier coping mechanisms and improve their interpersonal relationships. The findings underscore the importance of considering both theoretical and empirical perspectives in developing effective interventions for BPD, offering a foundation for future research to build upon. So far, this was the first study conducted in the Czech Republic considering BPD patients in virtual reality and will be developed within the study including patients with social phobia as well.

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