The Development of a Common Factors Based Virtual Reality Therapy System for Remote Psychotherapy Applications

How we can use virtual reality and electroencephalography to effectively treat isolated populations suffering from depression and general anxiety

By
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Abstract

Mental health disorders such as depression and anxiety affect one in five adults in the United States. According to the 2019 National Survey on Drug Use and Health (NSDUH), non-serious mental illnesses are found in 30.6% of young adults aged 18-25 years old and 25.3% of adults aged 26-49 years old. In 2020, the NSDUH found that only 44.8% of all adults living with non-serious mental illnesses sought treatment [1]. In 2020 and 2021 with the rise of the COVID-19 pandemic, 41.5% of US adults reported to have been struggling symptoms of an anxiety of depressive disorder [2]. With this added burden, the increase in social isolation during the pandemic, and unknown long term psychological effects of the past year and a half, the need for an effective remote psychotherapy treatment is even more evident. The objective of this research is to address the growing need for a remote psychotherapy solution that is both accessible for isolated patients and effective. One approach to therapeutic healing that is standard in counseling psychology is the use of psychotherapy based on common factors theory. This theory poses that there are several common factors that need to be addressed for healing to occur. This research focuses on two of the common factors that are most difficult to reproduce in remote psychotherapy: the therapeutic alliance and the therapeutic environment [3]–[5]. We hypothesize that the use of a virtual reality (VR) and neurofeedback based psychotherapy system specifically designed based on common factors theory will lead to better performance in the therapeutic alliance between therapists and patients and ultimately, better outcomes for remote psychotherapy patients. The following specific aims address this hypothesis:

Specific Aim 1: Design and Develop a Common Factors Based Virtual Reality Therapy for Remote Psychotherapy Applications. A full common factors based VR psychotherapy system

was developed using Unity3D, Autodesk Maya, and MATLAB. Key components of the design include three virtual environments designed based on key elements of restorative environments (Forest World, Log Cabin, and Freud Therapist Office), two therapist avatars based on Jungian archetypes for healing (Woman Healer, Sage), a neurofeedback system using electroencephalography (EEG), a therapist interface, and a patient interface. Success was measured based on the prototype's ability to be a fully functional remote psychotherapy treatment, its adherence to restorative environments design elements, and its adherence to Jungian archetypes design elements.

Specific Aim 2: Determine the functionality and usability of the novel common factors based VR therapy system for therapists. The first step to determining the efficacy of a novel treatment system in psychotherapy is to analyze the functionality and usability of the treatment for therapists. Specifically, this study examined if therapists are able to effectively use this system for the remote treatment of depression and general anxiety. A proof of concept study was conducted with 21 observing counselors in training to examine the functionality and usability of the VR enhanced therapy system for therapists. The session was conducted with a professional therapist and a patient using the VR system in another room. Measures from this study will include the 1. Client Reactions Systems, 2. Perceived Restorative Scale, 3. Session Evaluation Questionnaire, and 4. Presence Questionnaire. Success will be determined by examining the neutral score for each these metrics, and comparing the scores received by therapists to the average. The treatment was considered successful if the novel VR treatments preforms as well or better than the average across all metrics.

Specific Aim 3: Determine the functionality and usability of the novel common factors based VR therapy system for patients. A proof of concept study was conducted to determine if the novel VR enhanced therapy is as good or better at reducing symptoms of depression and anxiety in patients

in comparison to existing CBT effects and to determine whether the therapeutic alliance is enhanced in VR therapy. The study examined examine 30 adults in Lawrence, Kansas and the surrounding areas with counselors playing the role as therapists in a solution focused counseling session. The patients were split into two groups: a control Zoom video chat based remote therapy session and the novel VR based therapy session. Measures from this study will include the 1. Client Reactions Systems, 2. Perceived Restorative Scale, 3. Session Evaluation Questionnaire, and 4. Presence Questionnaire. The treatment was considered successful if the novel VR treatments preforms as well or better than the control across all metrics.

Future Development and Research: Beyond this dissertation work, we plan to continue to develop more environments and avatars, determine relative efficacy of the therapy system through further human subjects' studies, and explore its use in the treatment of other populations including the military and other conditions including post-traumatic stress disorder (PTSD). At this moment, we are also pursuing opportunities for the commercialization of this work including obtaining a provisional patent and submitting a full international patent, exploring a licensing agreement with a company, and examining the viability of starting a new venture in the field.

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In 2018, right as I had just graduated from college, my friend and fellow graduate, Peyton, took his life. This is for him.

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CHAPTER 1: Background and Significance

Importance of Mental Health Care: Current State of Need

Mental health disorders such as depression and anxiety affect one in five adults in the United States. According to the 2020 National Survey on Drug Use and Health (NSDUH), mental illnesses are found in 30.6% of young adults aged 18-25 years old and 25.3% of adults aged 26-49 years old [1]. A common method of treating these conditions is counseling that is directly by a therapist or psychiatrist. In 2020, the NSDUH found that only 46.2% of all adults living with any mental illnesses sought treatment [1]. However, several barriers prevent patients from seeking treatment. These barriers include the stigmatization of mental illness, confidentiality and trust, difficulty identifying the symptoms of mental illness, lack of accessibility, and fear or stress about the very idea of seeking treatment for mental illness [6]–[10]. In 2020 and 2021 with the rise of the COVID-19 pandemic, 41.5% of US adults reported to have been struggling symptoms of an anxiety or depressive disorder [2]. With this added burden, the increase in social isolation during the pandemic, and unknown long term psychological effects of the past year, the need for an effective remote psychotherapy treatment is even more evident.

Isolated populations

Isolated populations can refer to people who are geographically, psychologically, linguistically, or economically isolated. In psychotherapy terms, geographically isolated populations are populations where the nearest available therapist is too far away for in person therapy to be a viable option for treatment. For people who live in these areas, finding effective mental health care that meets their diverse needs can be a complex challenge influenced by individual, interpersonal,

community, and societal factors [11]. A common issue in rural communities is a shortage of providers, meaning that individuals seeking care may need to travel farther outside of their communities to find a counselor that can treat them. For minority groups or other individuals who may have specific needs, finding counselors who have adequate training or the willingness to treat them may be even more challenging. For example, we talked to one counselor in rural Kansas who said they were one of the few counselors in their area willing to treat people from the LGBTQ population, and thus saw clients from faraway communities and were consistently overbooked and overworked. In some areas of western Kansas, the nearest therapist office could be three hours (or longer depending on their specific needs) away by driving. To ask people to travel three hours or more every week there and back provides an immense barrier to treatment. Other factors that negatively affect access to treatment in rural populations include higher poverty rates, lack of transportation, individual and public stigma towards mental healthcare, and limited mental health literacy. All of which contribute to individuals in rural areas being less likely to seek professional help for psychological distress in comparison to those in urban areas [11]–[15].

Psychologically isolated populations refer to people who may find the idea of getting out of bed in the morning, getting dressed, leaving their homes, interacting with other humans, and talking to a therapist, impossible. People with social anxiety, mobility issues, worried about stigma associated with mental healthcare, or experiencing shame may not be able or willing to undergo in person treatment. Deciding to take the first step to receiving treatment is already a difficult, stressful, and vulnerable decision for many without considering the added element of going out into the public away from the privacy of one's home that is required for in person therapy. For many men, shame is a large barrier to help seeking. Many men have a difficult time disclosing their private selves and can come into psychotherapy with reluctance and resistance [16]. Even as

stigma for mental health treatment is being addressed in the media and mental healthcare is becoming more normalized in society, telemedicine can help lessen the initial barrier to treatment associated with stigma [17]. For people in need of psychotherapy with other conditions associated with high levels of shame such as trichotillomania, telemedicine can provide an effective alternative to in person treatment [18]–[21].

In this context, economically isolated refer to populations where the cost of in person therapy is prohibitive. According to the National Survey on Drug Use and Health 38.3% of people report the reason that they did not receive any mental health services is that they could not afford the cost [1].

Current Remote Therapy Options and Counseling During COVID 19

Currently, several remote psychotherapy options are available on the market in various forms of telehealth including video chat, text based, and phone call based therapy. Some examples of these treatments include BetterHelp, Talkspace, Zoom chat based therapy, online resources, educational seminars, and others. During the COVID-19 pandemic, social distancing guidelines prohibited in person therapy, thus most counselors used online remote services to conduct their sessions. Before the pandemic, only 39% of mental healthcare professionals reported using telepsychology, however since the start of the COVID-19 pandemic, 98% of professionals have used some form of telepsychology in their practice. In addition, before COVID-19 the vast majority of telepsychology was conducted via work phone, email, or text messages. Since then, the majority still use these technologies, however the use of services such as Zoom, Zoom Pro, Doxy.me, Facetime, and other services to conduct counseling sessions has increased tremendously. For both before and since COVID-19, virtual reality has rarely been used by mental health professionals

[22]. For clients in need of mental health services, the use of direct to consumer telepsychology services and e-therapy apps has increased. For example, from March to May 2020, Talkspace and Betterhelp both reported its new user count nearly doubled. The use and creation of at home wellness apps or mobile health (mHealth) apps is also increasing. Currently, an estimated 300,000 mHealth apps are available on the major app stores (Apple App Store, Google Play, etc.) with an additional 200 apps being created every day [23]. During the mid-2010s, mHealth apps were already used by 25% of US citizens and its market is predicted to reach $10.2 billion by 2023 with apps focused on wellbeing making up about 20% of the usership [24], [25].

With the widespread increase in the use of telepsychology, its effectiveness and limitations need to be better understood. Since the COVID-19 pandemic, therapists' attitudes towards telepsychology have shifted positively with therapists feeling more confident in providing effective care remotely. Therapists also reported high treatment effectiveness using telepsychology. However, since COVID-19 therapists reported experiencing a significant increase in burnout and ethical and privacy concerns about the use of telepsychology remain [22]. Despite the concerns, for many, online, remote, and telepsychology resources have provided a valuable lifeline during this difficult time.

However, the shift from widespread in person counseling to widespread remote counseling has meant both therapists and clients have had to adjust to this new paradigm of treatment. When therapists are no longer in the room with their clients, it becomes more difficult to recognize nonverbal cues and form connections with their clients. The most widely used forms of teletherapy are limited to audio and video interactions, which can restrict the feeling of presence with the counselor and limit the effectiveness of communication [26]–[28]. Likewise, since clients may be stuck at home or socially isolated, the environments for which treatment occurs may not be

conducive to healing. For example, consider a client who schedules an appointment with their therapist for a session to work through stress due to working from home. During the session, they see work papers, an overloaded calendar, visible due dates, and a packed to-do list all scattered around the room and in sight from where they sit in front of their computer screen. It becomes difficult to focus on healing with all these distractions present. Furthermore, isolated populations are particularly vulnerable to these struggles irrespective of the pandemic. The distance associated with teletherapy can risk eliminating the feeling of closeness and social connect that is essential to healing. For psychologically isolated populations, the prospect of opening a Zoom chat staring face to face directly with a therapist can cause too much anxiety for them. At the same time, with no visual of the therapist, it can become too impersonal. Finally, for the clients that struggle to even get out of bed, they ultimately must receive treatment in the same space in which the worst of their struggles have occurred [26]–[28].

Common Factors Approach to Therapeutic Healing

Common factors theory refers to the psychological theory that several common factors need to be present for effective therapeutic healing to occur. These factors include empathy, alliance, environment, expectations, positive affirmation, genuineness, and cultural adaptation of evidence-based treatments [3]–[5], [29]–[31].

Common factors theory was first introduced in 1936 by Saul Rosenzweig as an explanation for why diverse and theoretically conflicting psychotherapy procedures were able to achieve success. He noticed that there were several implicit or unrecognized factors that were present across a wide variety of successful therapeutic procedures and proposed that those unrecognized factors may actually be more important to therapeutic healing than the specific therapeutic technique [32].

Since then, Rosenzweig's assertion that all therapies have comparable effects and do not differ significantly from each other, or the Dodo Bird Effect, is a hotly debated topic in psychology. Several meta-analyses have analyzed the Dodo Bird Effect by challenging or attempting to confirm treatment equivalence. Some have found little or no significant difference in effectiveness when comparing active treatments with each other [33]. Others argue that contrary to the Dodo Bird hypothesis there was evidence of treatment difference for primary outcomes at termination with cognitive-behavioral treatments being incrementally more effective. However, the analyses still supported evidence of non-specific factors contributing to the overall effectiveness of different treatments in addition to specific factors present in treatment protocols [34]–[36]. Whether all treatment protocols are the same or some treatments are more effective than others, the evidence suggests that other factors common across different interventions, common factors, have an effect on the overall outcome of treatment. For example, Budd and Hughes assert that evidence suggests at least three effects that are both theoretically and practically important: 1. Therapist's allegiance to particular intervention contributes to the overall effectiveness of treatment, 2. The formation of a therapeutic alliance is central to effectiveness, and 3. Some therapists are more effective than others regardless of treatment intervention. They argued that while there may be conflicting evidence of the Dodo Bird theory, treating therapy protocol like drug prescriptions to be strictly followed may do a disservice to the individual needs of clients [37]. With this context in mind, this research aims to aid remote therapy by empowering counselors to administer treatment protocols as they see fit and instead aid the external common factors that may be hindered using the current methods of remote psychotherapy.

Since Rosenzweig's assertion of common factors and the Dodo Bird theory, much research has been done to determine exactly what are the common factors contributing to therapeutic healing.

Jerome Frank's book *Persuasion and Healing: A Comparative Study of Psychotherapy*, one of the most influential works in common factors theory, analyzed the history of psychotherapy and therapeutic healing across cultures all around the world to better understand the common motifs across all of them. He argued that successful psychotherapy must affect all three of biological, psychological, and social factors, thus he searched for common features related to all three domains. Four key common features were determined to be present across all forms of successful therapeutic healing, across all cultures, and throughout history. Frank's four common features are as follows: 1. Relationship Between Patient and Caregiver, 2. Healing Locale, 3. Therapeutic Rationale, and 4. Theoretical Task or Procedure [38].

The first common feature, the therapeutic relationship, posits that the patient must have confidence in their therapist and believe that their therapist genuinely cares for their wellbeing. Therapists must display caring and empathy for their patient through qualities such as active participation, warmth, empathy, and enthusiasm. The patient must believe in the therapist's expertise, trust in their therapist's acceptance of them, and trust that their therapist will continue to help them in their condition and believe in their ability to get better. The relationship is built on trust and understanding between both parties and is essential for therapeutic healing to occur [38].

The second common feature, healing locale, posits that the setting of therapy itself contributes to healing. Patients must feel like they are in an environment meant for healing, meaning it must be sanctioned by the value system present in that society. In the pre-industrialized world, therapy typically took place in a sacred building or temple, and if the therapy was conducted at home it was transformed through ritual. In the modern world, therapy is conducted at therapist offices, hospitals, or health clinics, all containing a form of scientific legitimacy for healing. A therapeutic setting should also act as a temporary refuge for their patients away from the stressors and

distractions of daily life. Patients should feel protected by the setting, so that they can feel open to explore their own emotions, confront complex issues, or participate in whatever other activity the therapy prescribes. Thus, the setting must as a distinct space away from the outside world with distinct boundaries to delineate them [38].

The third common feature, therapeutic rationale, posits that all successful therapies contain an underlying rationale for the symptoms or illness and a way to heal them. This rationale can give meaning to their patients are feeling the way they are, where the emotion distress is coming from, and what they can do to make it better. For example, a rationale could be that a patient's aggressive behavior is a result of past hurt or trauma, and thus, if that patient confronts those past hurts, they will become a kinder, more loving person. Western forms of psychotherapy such as Freud's psychoanalysis take this same framework for rationale. To Freud, the human psyche is a struggle between the instincts of Life and Death and helping patients to uncover those basic instincts in themselves can free them to put more energy into their life goals. In other cultures, the rationale follows the same framework, but must be consistent with the patient's worldview. More broadly, rationales must explain the sufferer's distress, specify their goals, and prescribe methods for attaining those goals. In some contexts, researchers describe the rationale as a myth as a way to emphasize that the most important thing for a rationale is not that is wholly and infallibly true, but that the patient believes it to be true [38].

The fourth common feature, theoretical task, posits that all forms of therapeutic healing contain a procedure for the patients to follow in order to heal. The patient must actively participate in the healing process allowing the therapy to serve as a vehicle for maintaining the therapeutic relationship, building the patient's self-confidence, and transmitting the therapist's influence.

Frank proposed that the combination of therapeutic relationship, setting, rationale, and task influence patients in order to promote healing [38].

The most developed and modern model of common factors is the contextual model of psychotherapy. The contextual model posits that there are three mechanisms in which psychotherapy produces benefits: 1. The real relationship, 2. The creation of expectations through explanation of disorder and the treatment involved, and 3. The enactment of health promoting actions. Most importantly, however, the contextual model suggests that before these mechanisms can be activated a therapeutic relationship must be established. Embedded in the three mechanisms of therapeutic healing are common factors that are present and necessary for healing. The common factors of the contextual model vary slightly across different sources, however some of the most researched common factors are as follows: empathy, alliance, environment, expectations, positive affirmation, genuineness, and cultural adaptation of evidence-based treatments. **Table 1** gives brief descriptions of each of the common factors and their role in therapeutic healing [3]–[5], [29]–[31].

Table 1. The common factors of therapeutic healing according to the contextual model and brief explanations of their roles in the healing process [3]–[5], [29]–[31].

Common Factor	Description	Role in Healing
Empathy	The ability for the therapist to identify with, share emotional state with, and understand the perspective of the client. This typically refers to the therapist being warm, kind, and understanding with the client.	Empathy is thought to be necessary for cooperation, goal sharing, and regulation of social interaction. Therapist techniques include active listening, silences for reflection, and friendly tone.
Alliance	The ability of the therapist and client to build a working relationship together. It has three components: the bond, the agreement about the goals of therapy, and the agreement about the tasks of therapy.	Alliance is a critical common factor for the creation of expectations and the implementation of health promoting tasks. It is also crucial to the development of trust between therapist and client.
Environment	The setting in which the therapy takes place. A therapeutic environment is one that is conducive to healing, gives refuge from daily life, and is comfortable for clients.	A therapeutic environment is a setting that allows clients to feel comfortable, safe, and open to being vulnerable. They should also feel safe from the stressors of their daily life.
Expectations	Clear communication between therapist and client about the rationale for treatment, plan of implementation, and goals of treatment.	Creating clear expectations for the client that they agree on can contribute to healing increasing trust between therapist and client and increasing belief in the rationale.

Positive Affirmation	The therapist's continued encouragement, support, and validation of the client.	Positive affirmation is an important tool to build trust and confidence in the client.
Genuineness	The therapist is viewed as trustworthy, honest, and caring by the client.	It is important that the client believes that the therapist is genuine in what they say and their desire to help.
Cultural Adaptation	The explanation, rationale, and treatment method must be acceptable to the patient based on their cultural background and worldview.	In practice, there are many ways to adapt treatment to different cultures including using the client's native language, pairing therapists with clients with the same cultural background, using rituals, and adapting rationale to match the cultural worldview.
Rationale	The belief in an underlying reason for the experienced symptoms and a plan for how the client can get better.	For healing to occur, the client must believe that the counselor understands what is going on with them and can help them get better. They must believe in the counselors rationale for treatment.

For the purposes of this research, we will focus on the therapeutic alliance and the therapeutic environment, because we propose that these are the two factors in which current remote therapy options struggle with the most.

The therapeutic alliance refers to the ability for the therapist and their client to build a working relationship with each other. This requires the therapist to build trust with their client and form a

partnership, so that the client can feel like they can work together with their therapist towards healing. In remote psychotherapy, it can be very challenging to adequately foster the therapeutic alliance. Therapists have several techniques to quickly build a relationship with their clients including mimicking body language and energy, building rapport, and probing their clients at the right moments. All three of these techniques are much more challenging remotely [39], [40].

The therapeutic environment refers to external surrounding environment in which the therapy takes place. For healing to occur, the client must be in a space where they feel comfortable, safe, and open to being vulnerable. Examples of key features of a restorative space include having plants present in the room, having large windows so that the outside world is visible, and having comfortable seating. Nature therapy takes this idea further by taking their clients out into the natural environment. Nature has been associated with healing for centuries in various cultures [38].

Remote Psychotherapy Product Design and Development Approach

This research approach for developing a solution for the need of a more accessible and effective remote psychotherapy system for isolated populations followed a bioengineering product design and development approach, the research track for this work, combined with the counseling psychology principles as a guideline of needs for a successful solution. The process followed in the development of this system included identifying the problem, researching, brainstorming, selecting a solution, developing a prototype, testing, and iterating on the design. One of the main concerns for the development was to ensure that the developed product would not only adhere to the counseling principles necessary for therapeutic healing, but also be engineered in a way that best utilized the technology in service to its application. The design approach utilized a interdisciplinary team across both bioengineering and counseling psychology in order to ensure

that the proposed solution would ultimately be most beneficial to its users, both counselors and clients. The remote psychotherapy system developed as part of this research has been filed for an international patent, **no. PCT/US2022/032164** (*Virtual Reality-based Psychotherapy System with Real-time Electroencephalogram Feedback*).

Identifying the Problem

As discussed before, the overall problem that this system is attempting to address is the millions of people in the United States and around the world in need of mental health care and not receiving any form of treatment. This solution addresses a portion of these people for which in person psychotherapy is not a suitable option for them and the current remote psychotherapy alternatives do not address their needs. One group who may be more likely to fall into this category include isolated populations, which can refer either psychologically, geographically, or economically isolated. For isolated populations, in person psychotherapy is not a suitable solution for them due to a variety of reasons including distance to the nearest therapist office, anxiety towards the act of leaving the home to receive treatment or the treatment itself, and economic barriers to treatment. In addition, current remote therapy options, such as videoconferencing, text based, and phone call based therapy systems, may also not be a suitable solution for them due to the need for a therapeutic space that is comforting and safe, and a need for effective and nuanced communication over distance. In simpler terms, a psychotherapy solution that addresses their needs would need to include: 1. A remote connection between therapist and client, 2. A way to ensure that the client is in a suitable environment for therapy, and 3. Tools to ensure that therapists are able to communicate effectively with their clients over distance.

Researching the Needs and Customer Discovery

Needs of the potential users of this system were identified through existing scientific research in counseling psychology, in particular using common factors theory, and interviewing, shadowing, and learning from counselors, counseling students, psychology experts and professors, and psychotherapy users. Specifically, as part of this research, counselors in rural western Kansas were interviewed, professors in counseling psychology at the University of Kansas were partnered with and interviewed, and students and locals in Lawrence, Kansas who were either currently going to or seeking psychotherapy. Some of the customer discovery was done as part of a graduate course at the University of Kansas, Biomedical Product Development with help from students Wade von Kleeck, Bonnie Reinsch, Coy Lobaugh, and Isaac Dunn. Needs and concerns shared from the customer discovery include addressing the integral role of body language and non-verbal cues that could be lost over distance, the healing power of nature, the need for a remote solution due to a lack of resources in rural communities, and a concern for conserving the human element with the addition of new technology into counseling.

Brainstorming and Selecting a Solution

Potential solutions were focused on determining an alternative to current remote psychotherapy options that more accurately addressed the common factors of therapeutic healing, specifically solutions that would ensure that the client could have a comforting environment no matter their circumstances at home and address concerns of adequate communication over distance necessary for building rapport and fostering a therapeutic alliance. A remote psychotherapy system using virtual reality (VR) and electroencephalography (EEG) was chosen as a potential solution. VR was chosen as the mode of therapy because it can make users feel like they are in the virtual

environment. Thus, a virtual environment designed to be soothing and comforting can ensure that no matter where clients are, they are able to conduct their sessions in a healing space. EEG was chosen for its use as a tool to measure basic human emotions. This was hypothesized to be able to address the concern over communication and rapport building in remote or VR remote psychotherapy systems by giving counselors the necessary information they need to communicate effectively over distance. More information on the specific design of the psychotherapy system is included in **Chapter 2** and **Chapter 3**. The potential solution was assessed based on interviews with counseling experts, adherence the principles of restorative environments, the business model canvas, and interviews with potential users. A copy of the initial business model canvas and initial invention design is included in the **Appendix**.

Developing a Prototype

A prototype was developed with three therapeutic virtual environments, two therapist avatars that represent the counselor in the virtual space, a full functioning live display of EEG neurofeedback, a system for remote communication between counselor and client, and designs of the therapist and client interface. More information on the prototype is included in **Chapter 2** and **Chapter 3**.

Testing and Iterating

The prototype was assessed for functionality and usability for both therapists and clients. More information on the assessment of the prototype can be found in **Chapter 4** and **Chapter 5**.

Virtual Reality Based Psychotherapy

Virtual reality (VR) is a term that refers to technology that is created to give the participant the effect of being present in a new environment different from their current physical environment in which the objects have a sense of spatial presence. Typically, it involves a computer-based interface that creates a realistic environment intended to give participants the experience of feeling present in that environment and actively participating in their surroundings [41], [42]. VR is defined in this way, by its objective rather than its physical characteristics, because, throughout history, the term VR has been represented in a variety of different conceptual forms and technologies. Today, VR usually refers to head mounted displays (HMDs) such as Meta Quest 2 and HTC Hive Pro, which display computer graphics that simulate 360 degree, three dimensional environments to a participant through a wearable headset.

History of Virtual Reality

The concept of VR predates the development of VR technologies significantly. In Roman Gubern's book *Del Bisonte a la Realidad Virtual: La Escena y el Laberinto,* he proposes that the first widely known depiction of the concept of VR can be traced by to Lewis Carroll's world renowned 1865 novel *Alice's Adventures in Wonderland.* In the novel, Alice and her sister both dream of the same fantastical world as if they had entered a shared "virtual scenario" [43], [44]. However, Eric Steinhart traces the concept of VR to seventeenth century philosopher Wilhelm Leibniz who described an "organized system of virtual worlds available for human perceptual exploration" [44], [45]. The translation of these early conceptual depictions of VR into technologies wouldn't happen until 1956 with filmmaker Morton Heilig's "Sensorama". The Sensorama was a one person cabin where the spectator looked through a viewer displaying

stereoscopic, two images with slightly different viewpoints that when combined together give a sense of three dimensionality, films accompanied by vibrations in the person's seat, wind effects, sounds, and other stimuli. One of the most famous applications of the Sensorama was a motorcycle tour of New York City where users could feel like they were traveling through the streets of New York, with all its sounds and smells, on a motorcycle. The Sensorama was entirely mechanical and thus by many definitions would not be considered as fully VR, however it formed the basis for what the technology would become. In the 1960s, Ivan Sutherland considered the "Father of Virtual Reality" published a concept of virtual reality as a reality simulation tool and called it "The Ultimate Display". He also developed what he called the "Sword of Damocles", considered the first ever VR helmet [46]. Since then, VR has developed include a wide variety of technologies. Some examples of these technologies include Google Cardboard style mobile VR headsets (using stereoscopic technology), standalone or computer enabled HMDs with 3 or 6 degrees of motion, and cave automatic virtual environments (CAVE). Advancements in computer graphics and the introduction of technologies such as controllers and haptic feedback systems has made VR more immersive and affordable. VR is also being used in a variety of different industries including entertainment, education and training, healthcare, and psychology.

Virtual Reality Use in Physical and Mental Healthcare

Virtual reality (VR) has long been proposed as a powerful and useful tool in the healthcare sector, because of its heightened sense of presence in simulation applications, and its ability to give the users a heightened emotional response in comparison to other forms of media. VR has been successfully used as a medical simulation and training tool [47]–[51]. It has also been successfully used in the treatment of post-traumatic stress disorder (PTSD), various phobias, and anxieties. For these treatments, VR is typically used for a treatment called virtual reality exposure therapy

(VRET). In VRET, counselors guide their patients through a VR experience that simulates the traumatic experience, exposes the patient to the feared stimuli, or puts the patients into situations that make them feel anxious. VR is especially helpful in these applications in comparison to other exposure therapies because it is more controlled, regulated, and accessible in comparison to real life exposure therapy and is more emotionally stimulating in comparison to exposure therapy with other forms of media such as video [52]–[61]. VR has also been successfully to help foster better self-body image, self-compassion, and compassion in others [62]–[65].

As mentioned before, one key benefit to VR is its ability to provide users with the feeling of presence. Presence refers to the experience of 'being there' in an environment. When users feel engrossed in their virtual environment, lost in their surroundings, and forget the physical environment outside of VR, then they are experiencing presence. In comparison to other forms of media, such as video or audio, VR shows a much higher ability to give users the feeling of presence. At a basic level, VR is a powerful tool for presence because it blocks visual of the outside world, uses graphics that convey three dimensionality, and gives users a 360° view of the virtual world. Developers can add additional features to increase the level of presence including interactivity with the environment, haptic feedback, sound effects, and smell [66]–[68]. A common criticism for VR is that it can lead to cybersickness for its users. One explanation for cybersickness is the incongruence between the visuals from the virtual environment and other sensory inputs such as the sense of motion. Some research suggests that presence and cybersickness are negatively related [67], [69]. In psychotherapy applications, giving users a strong sense of presence has important benefits. For example, with a strong sense of presence, users may experience a virtual environment in the same way that they experience a physical one, evoking the same emotions and reactions. When users feel the experience of 'being there' and are

fully immersed in that experience, they may also react in the same way as if they were there, both emotionally and physically [70]–[73]. For psychotherapy applications, the connection between presence and emotional response is extremely important. Remember that one of the common factors for therapeutic healing is the therapeutic environment. Thus, providing a user with a virtual environment designed with the characteristics of a restorative environment could induce the same emotional response as a restorative environment in the physical world. Meaning that potentially remote users of VR psychotherapy could get the same feeling of comfort, safety, and openness to being vulnerable necessary for healing from the comfort of their own home no matter their physical situation may be [74].

In addition to the treatment of anxieties and phobias through VRET, VR has also been proposed as a useful tool for the treatment of generalized anxiety and depression [75], [76]. In contrast to exposure therapy, depression and generalized anxieties are typically treated through psychotherapy or counseling where the environment is not simulating an exposure to real world stimuli. Thus, in this case, VR does not act as a simulation tool, but instead as a counseling tool to either establish a restorative environment or help clients confront a specific issue they are dealing with. Depression is treated with a wide variety of different therapy protocols, methods, and modalities, thus for VR to be useful it must either be an adaptable tool for counselors to use across different contexts or address a specific aspect of healing. VR has been used successfully to help clients embody self-compassion, help clients build mutual empathy, treat depression in college students with positive psychology, treat depression in young adults with VR enabled personal construct therapy (VR-PCT), treat major depression with behavioral activation, treat depression with cognitive behavioral therapy (CBT) and treat depression with group therapy (VRGT) [62], [77]–

[83]. VR has also been used successfully in college counseling centers to treat generalized anxiety [84].

Nature Therapy

Nature has long been associated with therapeutic healing. In many different cultures, it was very common for religious leaders, shamans, and healers to journey with their clients into nature, walk and talk with them, and have a spiritual, physical, and mental experience towards healing. For example, in Norway, the concept of friluftsliv or outdoor living has long been with healing. For Norwegians practicing friluftsliv, time spent in nature strengthens neighborhood ties, reduces crime, stimulates social interactions among children, strengthens family connections, assists new immigrants coping with the transition, and is cost effective for health benefits. All of which are associated with increased community and human health [85]. From these origins and with scientific research into the healing properties of nature, the practice of nature therapy began. The view of nature as a therapeutic setting comes from its properties as a live and dynamic environment, one that was there long before the client gets there and that will remain long after. Nature therapy in practice can be exemplified by Dr. Ronen Berger, who successfully runs nature therapy programs in Israel. One example from his practice is of a boy named Joseph who was having communication problems and social difficulties. Joseph was not comfortable in the counseling room at his school, so instead he and his therapist went for walks outside his school by a riverbank. Overtime, Joseph found a specific spot to his liking and began gathering sticks and stones to make the space his own. In this case, nature acted as a partner in the therapy process, giving Joseph autonomy over his therapy space leading to a comfortable, safe place for him to heal [86]. The positive properties of nature therapy can be utilized with VR by building virtual natural environments. Exposure to nature in VR has been shown to reduce stress, promote relaxation,

improve mood, and improve well-being [87]–[89]. For urban populations, elderly adults, or anyone where nature is not easily accessible, nature in VR can provide a positive alternative. Incorporating elements into VR such as natural sounds in a virtual forest has also been shown to reduce stress [90]. Some research has begun considering the design considerations for VR based nature therapy using environments such as forests and garden in a game concept [91].

In this proposal, it is proposed that VR environments designed specifically with the characteristics of restorative environments can help increase the effectiveness of remote psychotherapy by providing clients with a suitable therapeutic environment during therapy sessions.

Fostering the Therapeutic Alliance

One of the most researched common factors that has been found to have a large impact on therapeutic healing is the therapeutic alliance. Research has suggested that a good alliance and positive outcome to psychotherapy are related [92]–[94]. Fostering a strong therapeutic alliance requires therapists and clients to build to working relationship with each other built on trust. Therapists are trained to foster this relationship by initially building rapport with their patients, communicating clearly about goals for the sessions, and probing their patients at the right moments. To build rapport quickly, therapists are taught to mimic their patients body language and pick up on non-verbal cues. In addition, counselors build alliance by understanding client emotions, challenging those reactions to find deeper meaning, noting them for further exploration, or validating how their clients feel. Accurately representing how a client is feeling in a given moment and providing a convincing rationale for those feelings is a common technique for building trust across many different therapy modalities. For years, counselors have feared that conducting sessions remotely instead of in person would have a negative impact on the therapeutic

alliance. One of the most widely cited reasons for resisting the adoption of videoconferencing based counseling in their practices is the perceived interruption to the therapeutic alliance even in cases where clients felt no distinct difference in the relationship [95], [96]. Since the COVID-19 pandemic with the rapid adoption of remote psychotherapy practices, many studies have analyzed the effects on this change on the alliance and found that videoconferencing sessions compare favorably to their in person counterparts. In fact, with certain, fostering the therapeutic alliance became easier. Online therapies can lead to clients feeling more comfortable ("at a safe distance"), less scrutinized, less self-conscious, and with a greater sense of personal control. Researchers have identified several key skills for establishing a therapeutic alliance in remote counseling including regularly checking in on client emotions, intentionally using body posture, facial expressions, and voice tone, 'leaning in' to the screen, experimenting with the virtual background, focusing on virtual eye contact, and giving clients shared control over the screen and technology [96]. For these clients, the shift to videoconferencing has been a welcome change, and it provides a glimpse at an opportunity for other remote counseling services to reach those that still do not find counseling accessible to them.

With evidence that video counseling can suitably facilitate a strong therapeutic alliance, it might not seem necessary to introduce new technology to help support therapist and client communication. However, for those in which videoconferencing is not suitable, such as those proposed in this work, the need for additional communication tools is necessary. For example, for the psychologically isolated who may find the face-to-face contact of video chatting too invasive, personal, and anxiety inducing, VR psychotherapy with the use of therapist avatars as an added layer of separation and anonymity may be more suitable. In addition, as outlined in the VR psychotherapy section, VR psychotherapy is a more suitable option for anyone in a stressful or

otherwise unsuitable environment for therapeutic healing. For all the benefits of VR psychotherapy described previously, the loss of non-verbal cues, facial cues, and added separation to communication may make it more difficult to foster the therapeutic alliance. In addition, several of the key skills identified as necessary for the remote facilitation of the therapeutic alliance become more difficult or impossible. Certainly, these challenges could lead counselors to be more hesitant to adopt remote VR psychotherapy into their practice. It is proposed that the live display of real-time electroencephalography neurofeedback data could give the necessary insight into their clients' emotions to foster a strong therapeutic alliance in VR remote psychotherapy.

Electroencephalography (EEG) has been used extensively to identify people's emotions including classifying basic emotions such as happiness and sadness, determining students' engagement levels, improving focus through serious games, helping promote wellness through relaxation training, and quantifying human stress [97]–[101]. It has also been found that a single frontal (FP1) electrode EEG is sufficient in identifying these basic emotions [100], [101]. Commercially, EEG headsets have been used in hundreds of wellness apps and neuro games. Several commercially available EEG headsets include Neurosky Mindwave Mobile 2, Emotiv EPOC+, and the MUSE 2 headband. A review of several commercially available headsets found that the MUSE headset was sufficiently accurate for drowsiness detection with a minimum reported accuracy of 83.3% and a maximum reported accuracy of 99.1%. In comparison, the Neurosky Mindwave headset had a reported accuracy that ranged from 31 – 97.6% [102]. Commercially available headsets were also sufficiently accurate to differentiate between cognitive states such as anxiety levels and tiredness [103].

In EEG, brain activity levels and thus emotions are associated with the frequency levels of the signal. EEG signals are processed using Fourier transforms and characterized across frequency

ranges or bands. In order from lowest arousal to highest arousal, the frequency bands are as follows: delta, theta, alpha, beta, and gamma. Delta, characterized from 0.1 – 3 Hz is associated with deep or dreamless sleep. Theta, characterized from 4 – 7 Hz is associated with dreaming. Typically, if a person's EEG shows high levels of theta, then they are either dreaming or in a super relaxed semiconscious state commonly associated with just waking up or just falling asleep. Alpha, characterized from 8 – 12 Hz, is associated with relaxation. Biofeedback focused on Alpha waves is commonly used for mediation training and relaxation techniques. The practice of mindfulness training or mindful meditation is associated with a positive increase in Alpha EEG waves and reduction in stress and increase in problem solving [104]. Beta, characterized from 12 – 30 Hz is associated with alertness or focus. Typically, when someone is doing something very challenging or mentally stimuli, it is associated with high levels of beta. In the Counseling Laboratory for the Exploration of Optimal States (CLEOS) lab run by Dr. Barbara Kerr, clients are trained to shift focus between alpha and beta by doing mindfulness exercises (alpha) and then answering trivia questions (beta). Gamma, characterized by frequency levels greater than 30 Hz, is associated with creativity and flow. When people are so engrossed in doing something that they love that they lose track of time, they are experiencing flow or high levels of gamma. For creative people, such as artists, musicians, or writers, doing their respective activities will put them in flow. Definitions of the boundaries for different frequency bands can vary across publications, particularly with delta and beta bands. Boundaries for Delta waves can range from 0 – 6 Hz and for Beta waves 12 – 50 Hz. Differences in power across EEG frequency bands in resting state has also been associated with different psychiatric conditions suggesting the possibility of EEG as a potential tool of diagnostics [105]. Different combinations of these frequency bands have been associated with other base emotions including engagement, attention, and anxiety [97].

In the context of psychotherapy, EEG has been used successfully as a tool for neurofeedback training to reduce symptoms in people with major depressive disorder. Neurofeedback training helps clients learn self-regulating techniques by allowing them to view real-time EEG data of their brain with a psychologist helping them focus their emotions [106]. An integrative counseling approach that incorporates neurofeedback training into standard counseling has successfully benefited clients with insomnia, anxiety, obsessive compulsive disorder (OCD), and depression [107]. Biofeedback, including EEG, has been proposed as a large untapped opportunity for its incorporation into behavioral healthcare. Used properly, it could help psychologists to blend technical and humanistic techniques to have fuller psychotherapy interventions that help clients achieve their optimal health [108]. EEG neurofeedback is also proposed as an important tool to improve communication between therapist and client. EEG has the potential to provide objective information for quantifying therapist rapport, can help therapist's cue into client emotions to form an empathic bond, and give insight into clients' cognitive states for further exploration [109]. On its own, neurofeedback may not give enough information to understand the client's mental state beyond arousal. However, with the added context of a counseling session, EEG could provide valuable insight into client emotions that might be missing during remote psychotherapy. Consider a counselor conducting in-person therapy with a client. They may ask the client a probing question and notice that the client is feeling uneasy in response to the question. At this point, the therapist can do several things in response to this information, they can probe further, ask the client directly, comfort the client, or note the information for later. However, consider the therapist in the exact same situation conducting VR remote psychotherapy. Without any feedback information, they would be unable to respond to how their client is feeling and may be completely unaware. Real

time EEG neurofeedback can give therapists the information necessary to address situations such as these, despite being remote with no vision of the client.

It is proposed that the real time display of emotions during therapy sessions using EEG can help facilitate therapists' ability to make connections with their patients and thus can help facilitate the therapeutic alliance. Thus, remote VR psychotherapy that incorporates EEG neurofeedback can help enable the benefits of VR and also give therapists the ability to build a therapeutic alliance despite this modality's limitations.

Neurofeedback Design Choices, Filtering, and Data Processing

For the design of the neurofeedback system, two major concerns were considered: The usefulness of the live display of the neurofeedback system and the accuracy of the EEG data displayed, the correlation of EEG data with client basic emotions. For the prototype, the intension of the neurofeedback design was to make sure that the display, EEG hardware and EEG software used for the system gave counselors enough information to accurately assess whether the EEG system was useful to them in their practice. Several commercially available headsets were assessed with the goals being to use a relatively inexpensive commercially available headset, comfortable enough to wear while wearing a VR headset, and with enough accuracy to be useful for counselors. The EEG headsets in contention for use included Neurosky Mindwave Mobile 2, MUSE 2 Headband, OpenBCI EEG headset, and Emotiv Insight, because of their relative availability and use in research. The MUSE 2 Headband was chosen for the final prototype because of its relatively high accuracy, from 76 – 98%, availability of open source software tools in MATLAB, comfort and size, and relative price, $200 [102], [110]. The MUSE 2 Headband has also been found to be sufficient for conducting event-related brain potential (ERP) research without the use of event-

markers [111]. This means that the MUSE 2 headband could be successfully used to identify when an external stimuli or event was present, for the purposes of this research, a change in emotional state. EEG data from the MUSE 2 headband has also been used to successfully identify cognitive fatigue, brain performance, mental state, and attentional response [111]–[114]. A full explanation of the EEG hardware design process is included in **Table 2**.

Data was recorded from the MUSE 2 headband at a sampling rate of 256 Hz, the raw signal was pre-filtered with a 60 Hz notch filter based on the recommendation from the Krigolson lab for processing EEG data using the MUSE 2 headband. The raw signal was subsequently filtered for each individual frequency band associated with the different emotional states using a bandpass filter: Alpha (8 – 12 Hz), Beta (12 – 30 HZ), Gamma (30 – 60 Hz), Theta (4 – 7 Hz), and Delta (low pass filter at 3 Hz) [111]. For the purposes of its use in counseling, the EEG frequency bands are intended to be useful for identifying client emotional states in the context of a counseling session. For example, beta waves are associated with alertness and focus, however in the context of a counseling session a spike in beta waves could be associated with heightened anxiety. In addition, low values of beta waves could be indicative of a client losing focus during a session or of a client feeling calm. Counselors can use their understanding of their clients in the context of what's being said during a counseling session in conjunction with noticeable changes in the power of various frequency bands to ultimately determine how to address their clients in different situations.

Neurofeedback Use Beyond Livestreaming and Treatment Tracking

Beyond the real time benefits during therapy sessions, neurofeedback could be useful for therapist to track their treatment and the progress of their patients. With the data collected from EEG, therapists will be able to see how their patients are feeling in their sessions, and over time they will be able to see trends of arousal, engagement, and attention throughout. This way therapists will be able to track how well their patients are progressing in their treatments. It can also be useful to see which techniques the patients respond to the most, and thus, therapists can adjust accordingly.

Conclusion

Mental health disorders such as depression and anxiety affect millions of people in the United States alone. In addition, less than half of all adults living with any mental illnesses receive any treatment at all for their mental health conditions. Several barriers prevent patients from seeking treatment including the stigmatization of mental illness, confidentiality and trust, difficulty identifying the symptoms of mental illness, lack of accessibility, and fear or stress about the very idea of seeking treatment for mental illness [6]–[10]. To address these barriers remote psychotherapy solutions have been implemented including text, phone call, and video chat based therapy systems. During the COVID-19 pandemic where in person psychotherapy was impossible these solutions have provided immense support for many of the people in need. However, certain limitations in current remote psychotherapy solutions including the challenges in providing a therapeutic environment and in facilitating the therapeutic alliance has meant that many other people are left behind and do not receive adequate treatment. In this report, it is proposed that a VR and neurofeedback based remote psychotherapy system specifically designed based on

common factors theory can make remote psychotherapy more accessible and effective for people in which current options are not sufficient.

CHAPTER 2: Design and Development of a Common Factors Based VR Therapy System

Abstract

In person psychotherapy can be inaccessible to many, particularly isolated populations. Remote psychotherapy has been proposed as a more accessible alternative. However, certain limitations in the current solutions including providing a restorative therapeutic environment and therapeutic alliance have meant that many other people are left behind and do not receive adequate treatment. A common factors based VR and EEG remote psychotherapy system can make remote psychotherapy more accessible and effective for people in which current options are not sufficient.

Keywords: Virtual Reality, EEG, Remote Psychotherapy, Common Factors Theory

Introduction

In the United States today, over two in five adults struggle with some form of mental illness. According to the Center for Disease Control (CDC) during the COVID-19 pandemic, 41.5% of adults reported to have been struggling with symptoms of an anxiety or depressive disorder [2]. One common method of treatment for these conditions is counseling that is administered directly by a therapist or psychiatrist. However, several barriers to treatment prevent patients from seeking the help they need. These barriers include the stigmatization of mental illness, lack of accessibility, and fear or stress about the very idea of seeking treatment for mental illness [6]–[10]. The National Survey on Drug Use and Health (NSDUH) found that only 46.2% of adults living with non-serious mental illnesses sought treatment [1]. A rough estimate using the values above and the population of the United States suggests that 63.6 million people adults in the US are experiencing anxiety or depressive symptoms and receiving no treatment for their conditions whatsoever. With this unmet

need, the increase of social isolation during the pandemic, and unknown long term psychological effects of the past two years, the need for an effective remote psychotherapy treatment is evident.

Isolated populations

One group of people that are adversely by the widespread use of in person therapy are isolated populations. These populations can refer to a wide variety of forms of isolation including geographically, psychologically, linguistically, or economically. In psychotherapy terms, geographically isolated populations refer to populations where in person therapy is too far away to be a viable option. For example, some people living in areas in rural Kansas may find that the nearest therapist that meets their needs could be three or more hours away by driving [11]–[15], [20].

Psychologically isolated populations refer to people who are inhibited from seeking in person therapy due to their mental or other psychological conditions. In these populations, getting out of bed in the morning, getting dressed, driving to a therapist office, and talking face to face with a therapist can feel impossible. In this context, economically isolated populations are populations where the cost of in person therapy is prohibitive [11]–[15].

Current Remote Therapy Options

For isolated populations where in person psychotherapy is not a suitable option for them, remote psychotherapy that is accessible and effective is a potential alternative. Currently, several remote therapy options, or telehealth solutions, are available in various forms including text, audio, and video chat based psychotherapy. Some examples of current options include BetterHelp, Talkspace, Zoom chat based therapy, online resources, educational seminars, and others. For many people, these resources have provided a suitable alternative to in person therapy that is more

accessible and works for their lifestyle. In addition, for large portions of the COVID-19 pandemic, these solutions were the only available options for therapy [22].

However, as both therapists and clients adjusted to this new paradigm of treatment, they have learned how the current solutions have a variety of challenges that have made effective remote therapy more difficult. For example, when therapists are no longer in the same room as their clients, it becomes more difficult to communicate on a deeper level and recognize nonverbal cues. Likewise, for isolated clients who may be stuck in nonrestorative, unsafe, or stress inducing environments, a treatment that is provided in that environment may not be conducive to therapy. For example, consider someone who is seeking therapy for symptoms of stress due to working from home. Now imagine that are in a Zoom session with their therapist, discussing ways to better deal with stress, and yet they are surrounded by this stressful environment. There are work papers everywhere around them and a large to do list. Maybe their bed is not made, and they have kid's toys everywhere and spilt coffee. It becomes increasingly difficult to focus while in that space, make a connection with their therapist, and grow towards healing. Furthermore, psychologically isolated populations may find the prospect of being face to face with a therapist over Zoom anxiety inducing or therapy without any visual of a therapist, phone call based therapy, too impersonal. Finally, for those psychologically isolated people who struggle to get out of bed in the morning, current remote therapy options require them to receive therapy in the exact same space in which their worst emotions, struggles, and times of vulnerability has occurred.

Theory: Common Factors Approach

Throughout this research article, common factors theory will be discussed as a framework for determining what makes a psychotherapy system conducive to healing, and ultimately as the guiding principle for developing a remote psychotherapy system that is accessible and effective. Common factors theory refers to the theory that several external factors, or common factors, in addition the actions or words of therapist, are essential for therapeutic healing to occur. Throughout the many years of research in common factors, several different factors have been discussed, however the main common factors that are generally found to be most important include empathy, alliance, environment, expectations, positive affirmation, genuineness, and cultural effects. As depicted in the introduction to this research article, two of those common factors that are increasingly difficult to address when therapy is conducted remotely are the therapeutic alliance and the therapeutic environment. Thus, the development of our remote therapy system will focus on addressing the limitations of current options on those two common factors [3]–[5], [32], [36].

The therapeutic alliance is the working relationship between a therapist and their client. Fostering the alliance means building a partnership built on trust, in which the client feels that they can work together with their therapist towards healing. This can be challenging in remote therapy because building that relationship requires deep forms of communication. Therapists are taught to use techniques such as mimicking body language and energy, building rapport, and asking probing questions at the right moments. All of which require a deep understanding of how their clients are feeling at a given moment, which can be challenging when separated over distance [39], [40], [92], [94], [115].

The therapeutic environment refers to the general surroundings of clients during therapy. For healing to occur, the therapeutic environment must be restorative or conducive to healing. Put simply, the environment must be a space where clients can feel comfortable, safe, and open to being vulnerable. Key features of restorative environments used in in-person therapy include having plants in the room, having large windows open to the outside, and having comfortable seating. Nature has also been used as a restorative setting. In fact, for centuries going out into nature has been associated with healing in many different cultures around the world [74], [85], [86], [116].

Virtual Reality Based Psychotherapy

Virtual Reality (VR) is a powerful technology that could be useful as a tool for addressing the limitations of current methods of remote psychotherapy, because of its ability to bring the user a heightened sense of presence and emotional response in comparison to other forms of media. VR has been used successfully in the treatment of post-traumatic stress disorder (PTSD), various phobias, and anxieties [52]–[58], [84]. It has also been used as a tool for fostering self-compassion, better body image, and compassion in others [62], [63], [65]. The ability of VR to instill to create the feeling of presence for its users can be used to help people feel as if they are in the virtual environment, “transporting” them from wherever they are into that space. This is powerful for its use in remote psychotherapy because it gives therapists control over their clients’ environments. Meaning, with carefully designed VR environments, even though a client’s physical environment may not be conducive to therapy, they can put on a VR headset and feel as if they are in a restorative environment that is conducive to therapy. Be it a space full of traumatic memories, a room full of stressful reminders, or a cramped space on the road, VR offers an escape from that.

We propose in this research that VR environments specifically designed with the characteristics of restorative environments can help increase the effectiveness of remote psychotherapy treatments by putting clients in an environment that is conducive to therapeutic healing.

Fostering the Therapeutic Alliance

As expressed earlier, the therapeutic alliance is the ability for therapists and their clients to build a relationship with each other built on trust. Therapists are trained to in a variety of different methods to foster the therapeutic alliance by building rapport quickly, communicating clearly, and probing their clients at the right moments. These tools include verbal following, mimicking body language, and picking up on non-verbal cues. Over distance much of the nonverbal communication is lost. Thus, therapists may be unable to gage how their clients are feeling in a given moment and building rapport can become more difficult. Thus, with every step of the therapy process constrained by the limited form of communication, building trust with their clients also becomes more difficult. Additionally, a crucial aspect of therapeutic healing is for therapists to push their clients outside of their comfort zones at the right moments. Therapists are trained to become adept understanding how their clients are feeling and noticing the moments where it would be appropriate to push further. However, in remote psychotherapy through video chat, phone, text based therapy it is increasingly difficult [40], [92].

Electroencephalography (EEG) has been used successfully to identify people's basic emotions in real time. For example, it has been used to identify people's focus during gaming, students' engagement levels, and people's anxiety levels in a variety of applications [97]–[99], [104], [105], [108]. Furthermore, a single frontal (FP1) electrode EEG can be sufficient in identifying the most basic levels of brain activity and emotions [100]. Brain activity levels are associated with different

frequency bands of the signal as follows. Alpha (8 – 12 Hz) is associated with relaxation, Beta (12 – 30 Hz) with alertness, Gamma (30+ Hz) with creativity and flow, Delta (0.1 – 3) with dreamless sleep, and Theta (4 – 7 Hz) with dreaming. Different combinations of these frequency levels have been associated with other basic emotions including engagement, attention, and anxiety [97], [105].

We propose in this research that a real time display of emotions during a therapy session using EEG can help therapists better understand how their clients are feeling during therapy and help foster a better working relationship with them.

Tracking the Treatment

In addition to the real time benefits during therapy sessions, neurofeedback can be a useful tool for therapists to track the treatment beyond a single therapy session. With EEG data collected over multiple sessions, therapists will be able to recognize trends of arousal, engagement, and attention, and see how their clients have progressed over time. They will also be able to compare their notes on individual sessions to EEG data, which could be useful in quantifying with techniques or approaches their clients responded to the most. Thus, therapists can adjust their treatments based on neurofeedback.

Design and Development of VR Therapy System

The purpose of this research is to develop a remote VR psychotherapy system for the treatment of depression and anxiety that is specifically addresses the requirements of common factors theory. Specifically, the goals of the design and development are as follows, a therapy system that: 1. Connects therapists to their patients remotely, 2. Contains restorative environments that are conducive to therapy, 3. Facilitates the therapeutic alliance through deeper communication and

real time neurofeedback, and 4. Packaged across a therapist and patient platform that is streamlined and contains the tools necessary for remote psychotherapy treatment.

To begin the development process, we first had to better understand the needs of therapists and their clients in remote psychotherapy. We started by interviewing several counselors across the rural areas of Kansas and found that many counselors longing for help and a new approach to therapy. One counselor described how some of their clients had to come from over four hours away each week to receive treatment. Thus, it was unsustainable for many clients and many dropped out. In addition to interviewing practicing counselors, design decisions were based on established literature on restorative environments, the therapeutic alliance, and common factors theory. The key system elements include the VR environments, therapist avatars, EEG neurofeedback system, therapist and patient interface, and the overarching remote therapy elements.

Design of Virtual Reality Environments

The design of the VR environments was based on the principles of restorative and therapeutic environments. Some of the key design elements include: 1. A connection to nature. Taking a journey into nature has been used for centuries as a therapeutic experience in many different cultures and has been found to be associated with healing. 2. An open world concept. One key necessity for clients to feel safe and comfortable for them to feel that they have agency. An open world concept gives them the ability to not only choose between environments but also move freely throughout those environments. 3. Diverse environmental elements. Restorative environments need to have a degree of variety to inspire curiosity and engagement in users. 4. Auditory elements. Audio utilized in the VR environments include rustling leaves, rushing water,

and soft background music. Further design elements will be discussed as they relate to specific VR environments developed.

The VR environments were developed in Unity3D using the GoogleVR plugin. Assets in the environments were created from a combination of free Unity store assets and developed assets in Autodesk Maya. Texturing for virtual elements were created in Adobe Photoshop.

Forest World

The first VR environment is the forest world environment. In this environment, users will be able to freely explore an open forest environment. Elements of this environment include a mountain, waterfall, ponds, hills, flowers, and varied terrain. The plants and greenery were used for their association with new beginnings and healing. Water was incorporated into the environment because of the soothing effect of rushing water. Finally, the archway of tress, the variation of terrain, incorporated clearings and nooks, and the backdrop of the mountain give clients places to explore without being overly distracted. These elements are inspired by the practice of nature therapy. During nature therapy, counselors walk with their clients outdoors, explore the natural environment, and go on a journey together. The intention of nature therapy is to utilize the healing power of the natural environment and also instill the feeling of building a working relationship by journeying together. In this same way, the forest world is built for exploration with free flowing movement, a variety of different natural elements, and small details and texturing. In addition, as counselors and clients journey together, clients can choose the space where they feel most comfortable to stop and relax giving clients the feeling of agency. Then, counselors and clients can conduct therapy sessions side by side in the space where clients feel most comfortable. **Figure 1** depicts the various design elements included in the development of the VR forest world.

Figure 1. Images of the entire VR forest world environment. Design elements visible in this image include, the forest and pathway, ponds and waterfall, and the mountain backdrop.

Log Cabin

The second VR environment is the Log Cabin environment. The intended purpose of the log cabin environment was to use the same principles of restorative environments that are present in the Forest World and transpose them into an indoor space. Restorative elements of this environment include large windows for a connection to nature, large comfortable furniture, soft soothing colors, and a crackling fireplace. Here clients have an indoor alternative to the forest world if they so choose.

Figure 2. An image of the log cabin environment meant as an indoor alternative to the forest world.

Freud Therapist Office

The third VR environment is the Freud Therapist office, which is inspired by Sigmund Freud's therapist office in Vienna, Austria. While the environment is not an attempt at a recreation of Freud's Vienna office, it uses the same elements that Freud valued in creating a healing space. These elements include large comfortable furniture, dark tones, ornate designs, evidence of expertise in the form of textbooks and awards, and walls covered in images. Another addition to this environment is the position of the client in the environment. In this environment, clients are laying on their backside on the couch much in the same way as many of Freud's clients were.

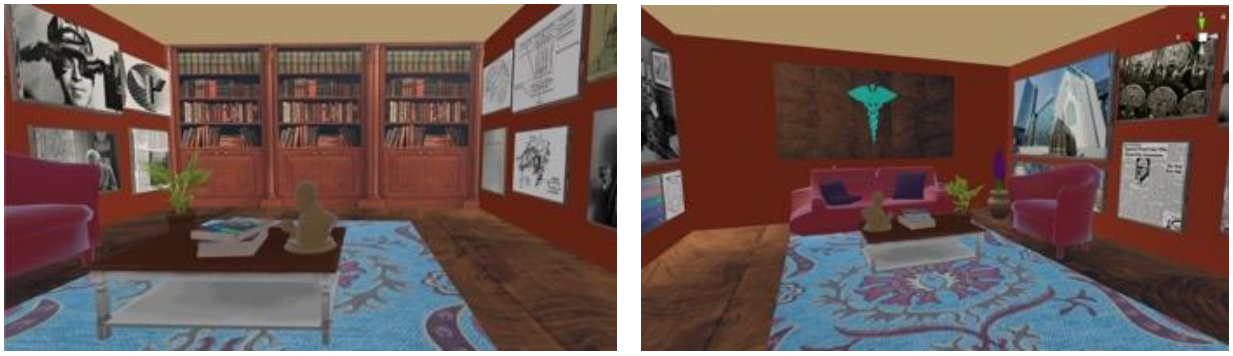

Figure 3. Images of the Sigmund Freud therapist office

Therapist Avatars

Therapist avatars are a crucial component of the VR psychotherapy system. Avatars are virtual characters that represent a person in the VR space. In this case it is necessary to include an avatar as a representation of the therapist for two reasons. The first is that without any physical representation of the counselor in the environment, it becomes jarring for clients to communicate with them. In an immersive VR space, it would feel as if a voice was coming from the sky. The second is that the use of an avatar in lieu of actual video of the therapist is intentionally meant to avoid the added stress that can arise from face to face communication with a counselor. This is particularly important for psychologically isolated populations [117].

The designs of the therapist avatars are based on physical representations of key therapist characteristics and Jungian archetypes [118]–[120]. Four key characteristics that clients look for in their counselors and value are 1. Expertness and Wisdom, 2. Compassion and Empathy, 3. Similarity and Liking, and 4. Genuineness and Trustworthiness [115]. These characteristics were mapped to the archetypes developed by Carl Jung. Jung developed different archetypes that represent certain personality traits, thus we were able to connect certain archetypal traits to their corresponding therapist characteristics. Two avatars have already been developed for this system.

The first, a sage, is meant to represent a wise old man and is meant for people who value expertness and wisdom in their therapists. The second, a healer, is meant to represent a woman Madonna figure and is meant for people who value compassion and empathy in their therapists. Future avatars will be developed for the other key characteristics and to provide a more diverse range of options. All of the initial designs for the avatars were created by graduate student and artist Kaylie Lyons. Those designs were then developed into virtual avatars using Autodesk Maya and textured in Adobe Photoshop.

Figure 4. The designs for the healer and sage by Kaylie Lyons Ridgeway

EEG Neurofeedback System

As mentioned in the introduction, one key component that is challenging in remote psychotherapy is the ability to foster the therapeutic alliance, because building trust, comfort, and a relationship together requires strong communication. In remote psychotherapy using video, phone, text based technologies, much of that deeper form of communication is lost. Thus, for the system to be effective in fostering the therapeutic alliance, some form of technology that could give therapists back some of the information that is lost over distance is needed. It is proposed that a real time neurofeedback system using electroencephalography (EEG) could provide the necessary information to therapists in real time and help them foster an alliance with their clients. The initial prototype for the therapy system uses a commercially available headset, Neurosky Mindwave Mobile 2, to measure and display in real time basic brain activity levels of clients during sessions. The guided user interface (GUI), real time processing of the signal, and real time display was developed in MATLAB using the Neurosky research tools package for MATLAB. The display is adjustable for therapists, where they are able to display any combination of the 1. Raw signal, 2. Frequency gradient, 3. Alpha waves, 4. Beta waves, 5. Gamma waves, 6. Delta waves, 7. Attention data, and 8. Meditation data. Alpha (8 to 12 Hz) is associated with relaxation, Beta (12 – 30 Hz) with alertness, Gamma (30+ Hz) with creativity and flow, Delta (0.1 – 3 Hz) with dreamless sleep, and Theta (4 – 7 Hz) with dreaming [97], [99], [100], [103], [105].

Therapist and Client Interface

Another important aspect to effective remote therapy is creating an interface for therapists and clients that is approachable and useful, because this is the main center in which they will interact with each other, and for therapists it is the platform in which they will be conducting therapy. For

clients, the interface needs to be streamlined, easy to use, and customizable. There also needs to be a space for the necessary information for clients to feel comfortable. For example, the interface should include information about potential therapists that they can choose from in the form of short biographies and preferences for avatars and settings. In this case, the system is built for mobile VR, and thus the client interface is designed for a mobile phone application. Designs for the client interface were developed in Adobe XD as a potential example for how a mobile app of the system would look like. Critical elements of this design include the ability to choose therapists by their images and biographies, the ability to choose a preferred avatar, and the ability to choose a preferred setting.

Figure 5. Design of the patient interface of the therapy system developed in Adobe XD.

The therapist interface was designed based on typical elements used by therapists during in person and remote therapy, interviews with four licensed therapists, and the incorporation of the neurofeedback elements. Some of the key elements to the therapist interface include a space for clients and their profiles (picture, demographic information, goals, and notes), live EEG signal display, calendar, inbox, and a space for notes. As mentioned before, the EEG display can be

customized to show whatever signals the therapist finds most useful. The design for the therapist interface was created in Adobe XD as a potential example for the interface in which this system could be built upon. Another concern in the design of an online therapist interface is privacy, which could be address by using a doubly secured webpage and a data encrypted signal connection.

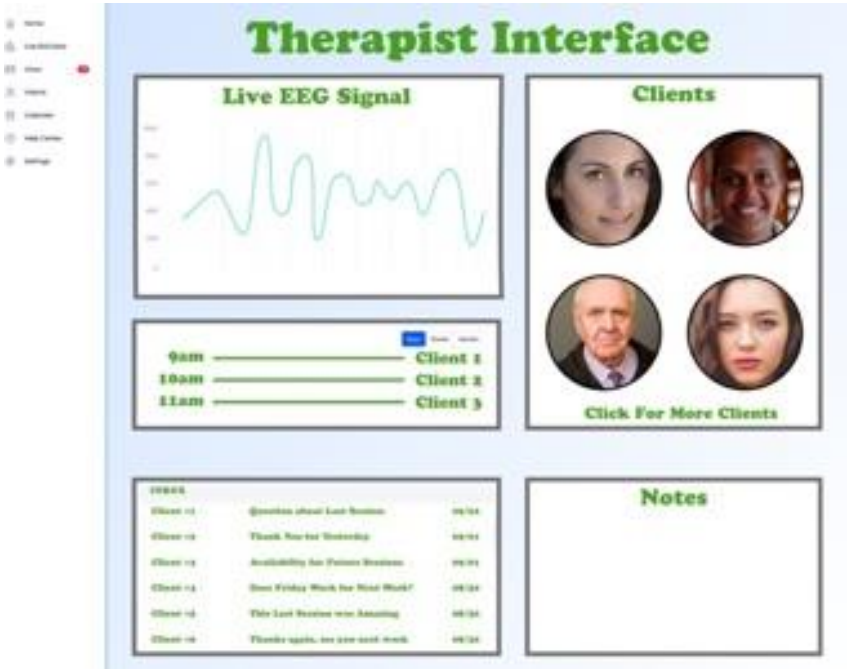

Figure 6. Design of the therapist interface of the therapy system developed in Adobe XD.

Overall Therapy System

The final integral consideration for the development of an effective remote therapy system for the treatment of depression is developing how the different parts of the system (VR environments, avatars, EEG neurofeedback system, therapist interface, patient interface) interact together to form a functioning for use. Considerations for the overall therapy system include how to seamlessly combine all of the different elements and how to securely connect therapists to their clients

remotely. For use in this research, the full therapy system will include the VR mobile headset, EEG headset, developed VR iPhone mobile app, live data processing of EEG in MATLAB, connection over Zoom, and live stream of client view in VR using Teamviewer. Thus, from therapists' perspective, the system connects them to clients via Zoom audio, they will be able to see live EEG data from the client, and they will be able to view what the client is viewing in VR in real time. From clients' perspective, they will be immersed in the VR with both VR and EEG headsets on and will be communicating with their therapists via Zoom audio. In practice, an online secure platform that combines these elements will need to be developed.

Future Developments

This research article is submitted in conjunction with a companion research article that focuses on the next phase of development for this project, initial proof of concept assessment of the system. In this study, the therapy system is critically analyzed by licensed counselors and counselors in training. The goal of this phase of the research is to better understand the needs of counselors during remote therapy and to determine the usability and functionality of the system from a therapist perspective. Four metrics are used in the study and are as follows: 1. Client Reactions Systems (CRS), 2. Perceived Restorative Scale (PRS), 3. Session Evaluation Questionnaire (SEQ), and 4. Presence Questionnaire (PQ). The CRS assesses the basic reactions to a therapeutic invention. In this context, it is being used as a way for the subjects to observe and assess the effectiveness of the therapy session [121]. The PRS assesses the restorativeness of a therapeutic technique, environment, or system [116]. The SEQ is a standard metric for evaluated therapeutic intervention and is correlated with the therapeutic alliance [40], [122]. The PQ assesses how well the VR technology of the system instills a sense of presence for its users. Ultimately, presence is

crucial for the client to feel engaged and immersed into the environment and the therapy session [123].

The next phase in this development is to analyze the usability and functionality of the therapy system for clients. In 2022, a 2x2 human subject study will be conducted for subjects that are experiencing depressive symptoms and seeking therapy. The same four study metrics will be used pre- and post- therapy sessions and results will be compared versus a control group of Zoom therapy. The purpose of this study is as a proof of concept study of this system for use in remote psychotherapy. Other future developments include the addition of addition VR environments, therapist avatars, and improved needed based on the results of the human subject studies.

Conclusion

This article outlines the design and development decisions necessary to address a growing area of need in the space of remote psychotherapy and telehealth as it relates to the treatment of depression and general anxiety in isolated populations. Currently, mental illnesses affect millions of people in the United States alone, and over 40% of those people struggling with mental illnesses receive no treatment at all [2]. Several barriers to treatment account for this discrepancy including stigmatization of mental illness, confidentiality and trust, lack of accessibility, and fear or stress about the very idea of seeking treatment [8], [10], [16]. Remote psychotherapy solutions have been proposed as a potential solution to address these barriers, in particular to increase the accessibility of treatment. However, certain limitations to current options including the difficulty of forming an alliance between therapist and client over distance and challenges to providing a therapeutic environment for treatment remotely has meant that many people are left behind by these solutions and do not receive adequate treatment. A new approach to addressing these

limitations based on common factors theory is outlined in this article. With new develops in VR technology and EEG, and careful design decisions focusing on building restorative, safe environments and a platform that gives therapists the tools they need to effectively build partnerships with their clients, it is proposed that we can build a remote psychotherapy system that is more accessible and effective for people in which the current options are not sufficient.

CHAPTER 3: Design Process and Decision Making

Purpose

The purpose of this section is to outline the design and decision making involved in developing a VR remote psychotherapy system that complements the common factors of therapeutic healing. In this section, we will cover the reasoning behind the overall design of the therapy system, VR environments, therapist avatars, and neurofeedback system. We will discuss the hardware and software choices for both the prototype used in this research and in addition propose a design for its use in practice.

Overall System Development

The research development team had several important goals for the overall psychotherapy system development including enhancing the common factors of therapeutic healing, enabling remote connection between counselor and client, ensuring client privacy, developing a usable counseling interface, and keeping the overall system affordable. Each design decision was made in service of these goals.

Key Elements

In addition to the virtual reality and neurofeedback system components, several other key elements needed to be implemented to ensure a functional remote psychotherapy system. Some additional key elements to the design include the implementation of software to connect therapist to client securely over distance, the choice of VR modality and headset, the choice of EEG hardware, and the development of the overall therapist platform during counseling. Each of these design considerations will be discussed below.

Remote Connection Software

The first key element necessary for conducting a remote psychotherapy session is a secure remote connection between therapist and client. With the onset of the COVID-19 pandemic, several videoconferencing and telehealth services emerged for therapists to conduct their counseling sessions such as Zoom, Zoom pro, Doxy.me, and Facetime. In fact, 98% of counselors have now reported to having used some form of telehealth in their practice [22]. Three main concerns were identified as it relates to the remote connection: Connection quality, Data privacy and encryption, and Ease of use. For the prototype developed for this research, we decided to connect counselors via Zoom Pro audio. The main reasons for this decision are that Zoom has been the most popular video conferencing service and has widely been used by counselors in their practice. Counselor and client familiarity was a concern, because with the added elements present in VR psychotherapy potentially causing added mental strain, keeping the other elements simple and easy to use is essential. Zoom also offers data encrypted connections between participants on using their meetings and we had no concerns with the connection quality via Zoom. Recently, as of November 2022, they now offer end-to-end encryption for meetings, which is the gold standard of data encryption. One thing to note is that we decided to use solely audio based connection. This is because we wanted this service to be beneficial for isolated populations who may find the face to face contact in videocalls to be anxiety inducing.

In practice, particularly for use in remote or rural areas, the secure connection between therapist and client is more complicated. While Zoom has seen widespread use across the country, it requires a strong wifi or cellular signal. In rural areas, areas in which accessible mental healthcare is difficult to find, this requirement may not be possible. Rural areas have consistently been ignored by internet and broadband companies leading to poorer Internet access and fewer

connection options [124]. In these areas, services requiring wifi or strong data signals may not be suitable. More research into this issue needs be conducted. However, one avenue for accessible remote psychotherapy in these areas where at home internet connection is not stable is to use public libraries. Nearly all local public libraries give community members access to wifi and computers, and many offer access to private conference rooms for computer use and videocalls. Many rural Kansas public libraries have also experimented with offering at home hotspot lending programs to give internet access to those in rural communities [125]. One possible way to reach the underserved rural populations with this technology would be to partner with local public libraries to give communities access to the hardware and software for VR remote psychotherapy in the library and provide private spaces for the counseling sessions. For those who wish to conduct counseling sessions at home, perhaps the VR psychotherapy system could be checked out from the library in conjunction with hotspot lending programs.

Virtual Reality Modality and Headset

The second key element to the overall psychotherapy system development was the choice of virtual reality modality. Two main choices were possible: standalone or computer tethered VR HMDs or mobile VR google cardboard style headsets. Potential options for standalone or computer tethered VR HMDs include HTC Vive Pro, Meta/Oculus Quest 2, or Pico 4. The benefit of using this modality of VR headset include higher computer graphics quality, 6 degrees of motion functionality, and better possibilities for increased immersion. However, the main drawback of these headsets is cost. Although, in the entertainment industry VR is becoming more widely used and less expensive, many of these headsets are viewed as a luxury item and are prohibitively expensive for much of our target population. Remember, 38% of people identified cost as the primary reason for not seeking counseling [1]. For example, the Meta Quest 2 is being offered for

$399.99 on their website and the HTC Vive Pro 2 is on sale for between $800 and $1400. Computer tethered HMDs also have the disadvantageous of requiring access to a high powered computer, typically an expensive gaming computer. One widely used option for VR mental health companies has been to use enterprise VR headsets such as the Pico 2. For the purposes of creating a prototype, this option was possible because they do not sell headsets for public use and only sell them in bulk to companies. In practice, more research should be done to identify the cost effectiveness of using VR enterprising services.

Mobile VR refers to headsets that use lenses in conjunction to cellphones to create the illusion of a 3-dimensional image. Users download a VR app on their phone, then slide the phone into a mobile VR headset, and finally wear the headset to use the experience. Mobile VR use apps stereoscopic side by side video that appears 3 dimensional when viewed in a headset. Limitations of mobile VR include lower quality computer graphics and 3 degrees of motion in comparison to 6. The benefits of this option include widespread use of smartphones in the United States and the relative inexpensiveness of mobile VR headsets. Mobile VR headsets are available online for as low as $13.

We decided to use the mobile VR modality, because our goal has been to make psychotherapy more accessible to isolated populations. Standalone VR headsets are expensive in comparison to mobile VR, and for people who are generally unsure about seeking counseling services, the price point for these technologies is prohibitive. In addition, in the United States, smartphones are present in 84% of households suggesting that a mobile app with this service would be accessible to many [124]. We believe that the immersion and presence capability in mobile VR is sufficient for quality VR remote psychotherapy services. For the purposes of prototyping, open source game engines such as Unity3D offer the possibility to port VR apps to both iPhones and Android smart

phones. We used an iPhone 7 plus and iPhone XR for this research, because of availability to the products. The specific mobile VR headsets we used for the research are as follows: B NEXT VR Headset, available on Amazon for less than $20 and the Hamswan 3D VR Glasses headset for $16.

EEG Hardware

For the neurofeedback system, we had two different design processes running in conjunction, one for prototyping and research assessment and one for use in practice. For the purposes of prototyping and assessment, our goals for selection were to use a relatively inexpensive commercially available headset, comfortable enough to wear while wearing a VR headset, and with enough accuracy to be useful for counselors. The EEG headsets in contention for use were the Neurosky Mindwave Mobile 2, MUSE 2 Headband, OpenBCI EEG headset, and Emotiv Insight, because of their relative availability and use in research. Each of these headsets were widely available at the inception of the research, have been used extensively in commercial apps, and have been used for a wide variety of neuroscience applications. The comparison of the potential headsets is outlined and scored in **Table 2**. Accuracy scores were found based on review articles of commercially available EEG headsets for use in drowsiness detection and use for drone control as well as identifying their use for mental health applications [98], [99], [101], [102], [110]. Although identification of drowsiness and drone control are not analogous to use in psychotherapy, the research focused on the accuracy of the frequency bands to real life applications. For the purposes of this research, counselors need to have trust that the values displayed on the frequency bands are accurate to the clients' brain activities and that the brain activity is correlated with clients' emotions. As long as counselors are able to recognize moments of strong client emotions during psychotherapy sessions given context, EEG neurofeedback can complement the practice of building rapport and alliance. This assertion will be assessed based on counselors' ability to build

alliance during actual counseling sessions using the VR remote psychotherapy system. Prices of headsets were acquired from company websites and other online vendors such as Amazon. Analysis of available developer tools focused on their customizability, ease of use for coding a user interface (preference for MATLAB use, because of researcher familiarity), and raw signal availability. Most headsets allowed access to raw signal data, however some required use of third party software or required a paid research package with obscured access to the raw data. This was rated poorly, because of the need to understand the raw signal without relying on a "black box" of code.

Table 2. Comparison of commercially available EEG headsets.

Comparison of Commercially Available EEG Headsets, Score from 1 - 5								
Headset	**Recorded Accuracy**		**Available Developer Tools**		**Comfort/ Size**	**Price**		**Total Score**
Neurosky Mindwave Mobile 2	31 to 97.6% [102]	**2**	Only available through purchase of Mindwave Research package, not much customization $500	**3**	Slightly clunky fit with VR headset	$100, no longer in stock	**5***	**10**
MUSE 2 Headband	76%, 78 to 98% [102], [126]	**4**	Free open source connection to MATLAB developed by University of Victoria, also connection through EEGlab	**5**	Fits well with VR headset on	$200	**4**	**13**
OpenBCI	79.4 to 96.4% [102]	**4**	Complete open source availability, however, needs to be assembled, developed, and created from scratch, complete customization	**4**	Completely customizable, but needs to be connected to board with wires	Need headband kit + Ganglion Board, $800	**1**	**9**
Emotiv Insight	76%, 80%+ [102], [126]	**4**	Free open source connection to MATLAB and Unity3D	**5**	Relatively clunky with VR headset	$500	**2**	**11**

Based on the decision matrix above, the MUSE 2 headband was selected. This headband was used for the final human subject study for this research, special aim 3. Initially, the Neurosky Mindwave Mobile 2 was selected, because it was already available to the researchers and was comparatively inexpensive. The three main reasons for switching away from the Mindwave Mobile 2 headset are as follows: Lack of availability of replacement headsets (no longer in stock on their website, Lack of support for developer tools (requires purchase of research tools), and the relative unreliability compared to other headsets. Across many studies, the Mindwave Mobile 2 headset scored dramatically different in terms of accuracy and the researchers felt that this could hinder counselors' abilities to trust the neurofeedback display. The MUSE 2 headband also allowed for free access to the raw signal, which gave the researchers the ability to filter the signal into the various frequency bands using literature values rather than relying on the commercial values given. The Emotiv Insight headset could also have been considered as a strong choice for inclusion, but the cost was prohibitive.

In practice, using a commercially available EEG headset for this application may not be a suitable choice, because it requires users to wear two headsets at the same time. Even with the thinnest EEG headsets, it was still quite difficult for clients to put on both of them and required help from someone else in the room. The researchers have proposed using a VR headset with EEG sensors built into it that would rest on the forehead. However, more development and research needs to be done into this possibility.

Overall Therapist Platform

Design for the overall therapist platform was developed by interviewing counselors, discussing basic in session counseling needs with experts in psychology, and ultimately relating all decisions

to the common factors of therapeutic healing. Two designs for the therapist platform were developed concurrently: a functional platform for use in the prototype and a theoretical design for how the platform could look in practice.

For the purposes of the prototype used in the assessment of this system, the goal was to create a platform with the minimum amount of development that included the components necessary for counselors to conduct therapy. The platform consisted of three elements: the live streamed EEG data, the image of the client's view in VR, and a space for the counselor to take notes. Because of the prototypal nature, each of these elements were included separately, but were all arranged on the laptop screen to be visible for the counselors during sessions. We also allowed counselors to arrange the three displays to their liking for ease of use. The livestreamed EEG was displayed using a MATLAB guided user interface, initially using MATLAB's GUIDE function, and later developed using MATLAB's app developer package. The choice of MATLAB for the neurofeedback system and the layout of the EEG signals will be discussed in the EEG neurofeedback section. The view of the client's VR was displayed to counselor using Zoom videoconferencing's screen sharing functionality.

For use in the future, design of a full therapist interface was developed based on counselor needs in remote psychotherapy using Adobe XD for visualization. The key elements to the interface design included the neurofeedback raw signal and frequency bands, a space for counselor notes, a section for client profiles which included demographic information, goals, signed documents, and session archives (Including EEG data), a calendar, and an inbox. The proposed layout is shown in **Figures 7, 8, and 9**.

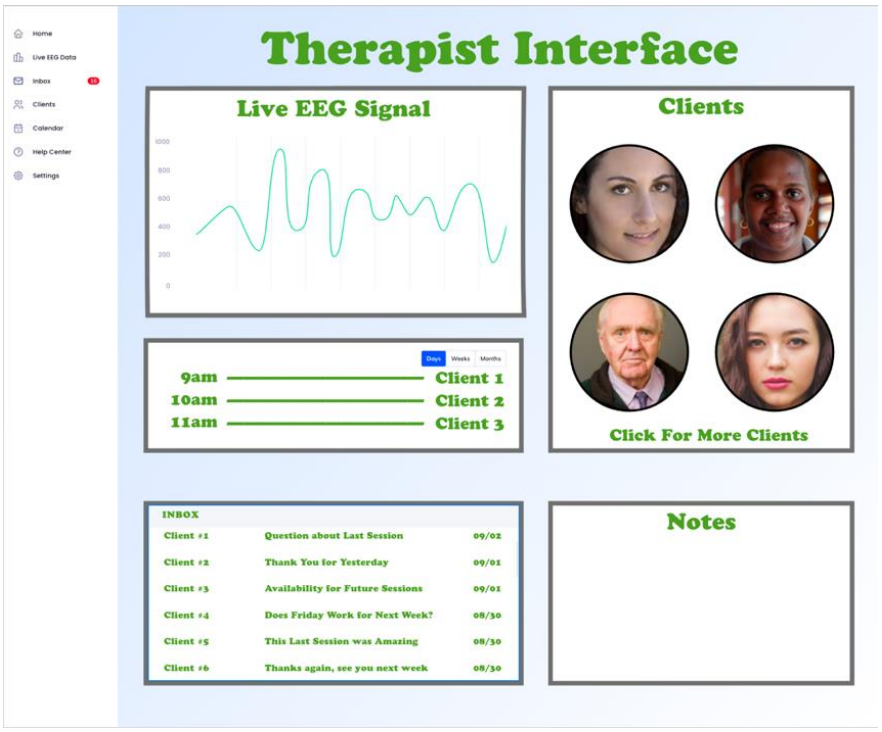

Figure 7. The proposed layout for the home page of the therapist platform designed in Adobe XD. The purpose of this design was to include the necessary tools for remote psychotherapy sessions all in one place while keeping a minimalistic design.

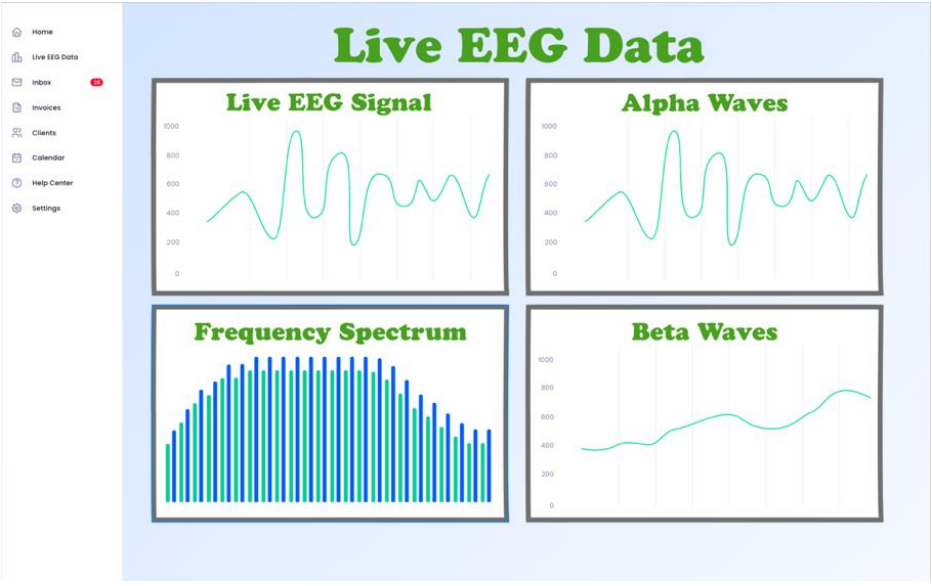

Figure 8. The proposed layout for the EEG livestream. Counselors would have the ability to switch out the windows to include the frequency bands of their choosing and arrange them it whatever way services them best.

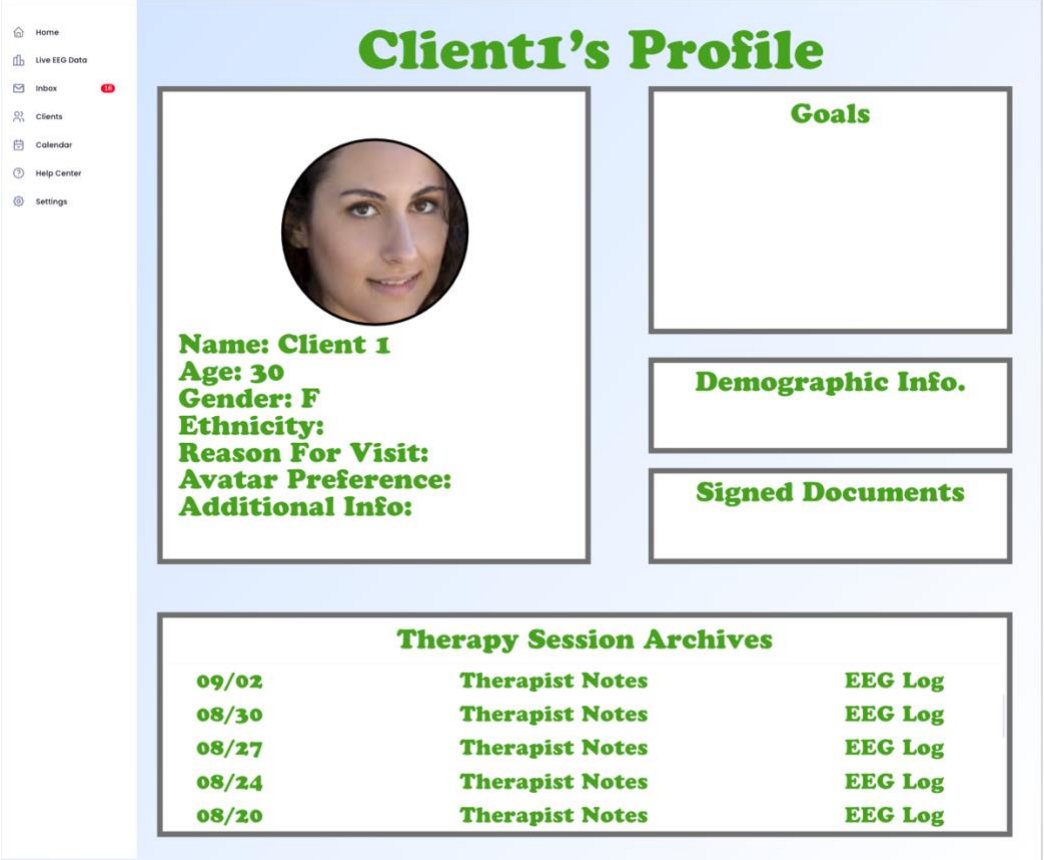

Figure 9. The proposed layout for the client profile page which includes a client snapshot, record of session and overall goals, demographic information, signed documents, and session archives with included EEG data.

In additional to the therapist interface, a client interface was developed. The goal of this design was to give clients an easy to use mobile application that gave them as much control and information about their counseling sessions as possible. Key features of this design include clients' ability to read counselor summaries and select preferred counselors, select preferred therapist avatars, and select preferred virtual setting. As part of the counselor profiles, counselors will indicate which avatars they prefer and other information on their background and counseling preferences.

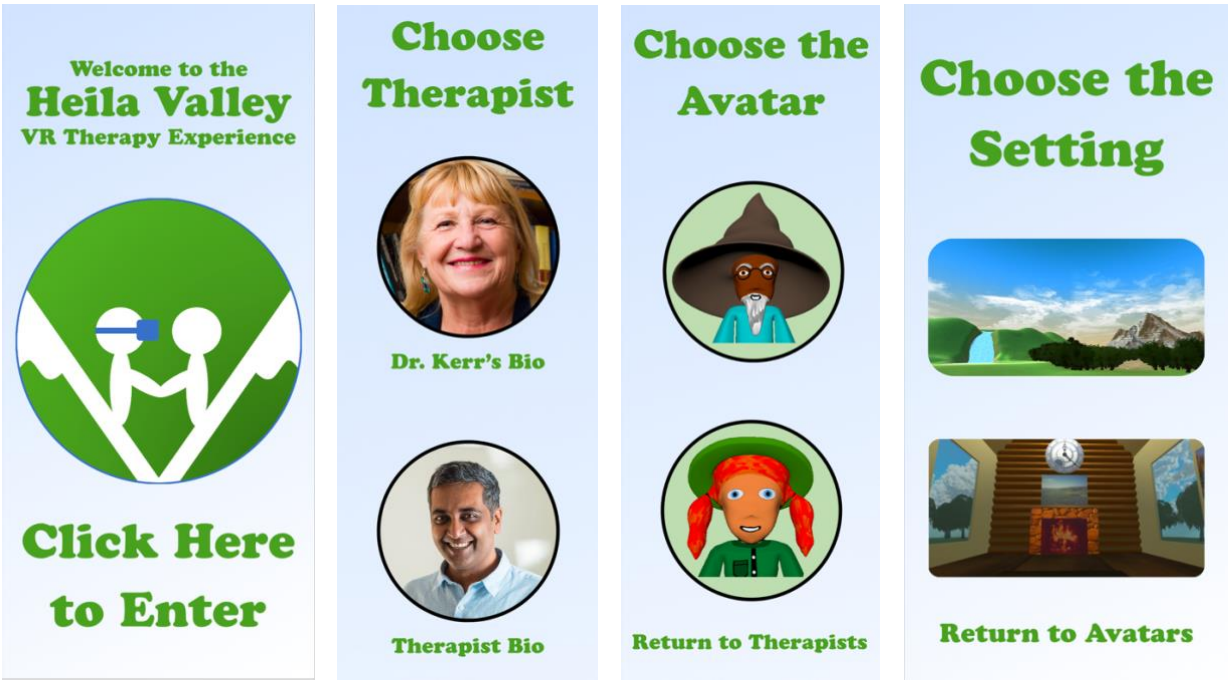

Figure 10. The proposed layout for the client interface and mobile application. The intended purpose of this design is to give the client control over their sessions and make the initial process as easy as possible.

Virtual Reality Environments

The purpose of this section is to outline the decision making behind the design of the virtual environments in the VR remote psychotherapy system. The virtual environments were designed with the principles of restorative environments in mind, meaning each decision was made in service to creating environment that help users feel more comfortable, safer, and more open to being vulnerable. Research into the design of counseling offices, nature and forest therapy, and healing spaces were used as inspiration for the design of the environments. Some basic overall characteristics of restorative environments include a connection to nature, soothing colors and sounds, a balance in complexity between too simplistic that its boring and too complex that its overwhelming, user interactivity with the environment, and client agency.

Software Selection

The virtual environments were designed used Unity3D game engine software. Unity3D was used because it is a completely open source game engine that has a package for google cardboard style VR games and has compatibility with Xcode for iOS applications. Objects in the environments were developed in Autodesk Maya or taken and modified from assets available for free on the Unity store or included in the standard assets package. Autodesk Maya was used for the assets, because it has cross-compatibility with Unity3D and was available for free through the University of Kansas's student subscription. All coding related to the environment physics and movement of the character as well as the environment was done using C#. Finally, the final Unity3D project was built and run in Xcode and ported onto a temporary free developer iOS app for use on an iPhone.

Conceptual Design of Environments

Three virtual environments were developed for the VR psychotherapy system: A forest world, a log cabin, and a therapist office inspired by Sigmund Freud. In addition to the virtual counseling environments, an introductory instructions scene, and environment selector space were created. Multiple virtual environments were necessary to give users more agency into their counseling experience. The first virtual environment developed was the forest world, which was chosen because of the healing power of nature. Several climates could have been selected for the natural environment including a mountainous region, coastal area, desert climate, or snowy environment. However, a forest environment was chosen, because of the benefits found from forest therapy and the representation of healing that comes from the color green. The forest world provides the basis of a soothing calming environment and gives the opportunity for other natural elements to be

included in this space that would not appear out of place including a waterfall, some ponds, flowers, rolling hills, and a mountain in the background. Variety within the environment in addition to variety in the different environments gives clients even more agency over their experience. The log cabin was chosen as an alternative to the forest world for those that prefer an indoor space. Log cabins are typically associated with feeling cozy, warm, and in the winter, they can provide a refuge from the outside world. Metaphorically, in this space, the virtual log cabin can act as a refuge for clients away from the stressors of their life. Finally, the last environment takes inspiration from Sigmund Freud's therapist office in Vienna, Austria. Freud's office in Vienna holds a special place in the history of psychology as the setting for one of the most influential psychologists. It is also a setting that has been referenced in many forms of media as a representation of a classic therapist office with the most popular example being a person talking to their therapist while laying on their back on a couch. Design decisions for each individual environment will be discussed in more detail below.

Forest World

The purpose of the forest world was to create a mystical natural environment that harnesses the power of nature and forest therapy and instills a sense of journey towards its users. When clients enter the environment, they arrive under an archway of trees shown in **Figure 11**. This is where clients first meet their counselors in the form of their avatars and are guided along on their journey. The pathway leads to a mountain in the distance, giving the environment a sense of grandeur and size, and calling back to therapeutic journeys up mountains to sacred temples. In fact, this archway was inspired by a forest pathway in Andechs, Germany that leads to an old monastery (which has now been converted to a famous brewery, Kloster Andechs) at the top of the mountain. The mountain was seen as a holy space, and monks who lived there lived in solitude and peace. The

other end of the pathway leads to an open clearing in which it is not entirely visible what lies beyond. This is deliberately done to encourage exploration from clients. If clients entered with view of the entire environment, all sense of mystery would be lost, and thus some excitement may also be lost.

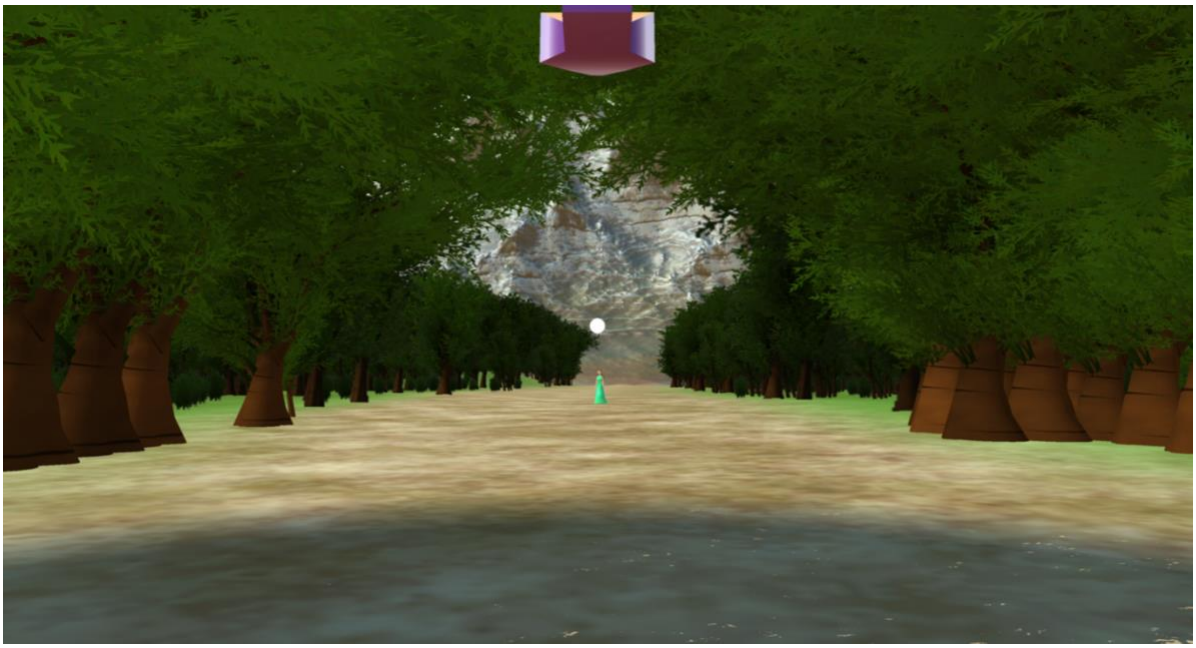

Figure 11. Image of the archway of trees and the first view for the client when entering the forest world. In the distance, the therapist avatar is visible, however much of the forest world is deliberately left obscured to instill a sense of mystery and adventure.

Around the bend from the archway of trees lies a pond with a flowing waterfall. Water is a substance associated with life, rebirth, and rushing water is a very soothing sound. As the client moves closer to the pond, grass and flowers begin to appear. An image of the pond and waterfall is shown in **Figure 12**. This design choice, having details revealed as the user gets closer to them, serves two purposes. The first is that it keeps clients interested in what they might find and the second is that it saves processing power to only load certain assets when the user is nearby. Another way to save processing power is called billboarding, which refers to having 2D "billboards" in place for objects far away that turn into 3D objects when approached. This was

done for all the trees in the forest scene. Another detail present in this part of the scene is that none of the objects are completely stationary. The grass and flowers sway in the wind to give a small sense of realism and the waterfall flows downward and creates a continually spraying mist. These are both details that are made to give the client little things to focus on, so that they do not get bored of the scene too quickly. They also move slowly and consistently, which is soothing to the eye. In the human subject trials, this location is where the therapist avatar takes their client to conduct the majority of the counseling session, because of its soothing nature.

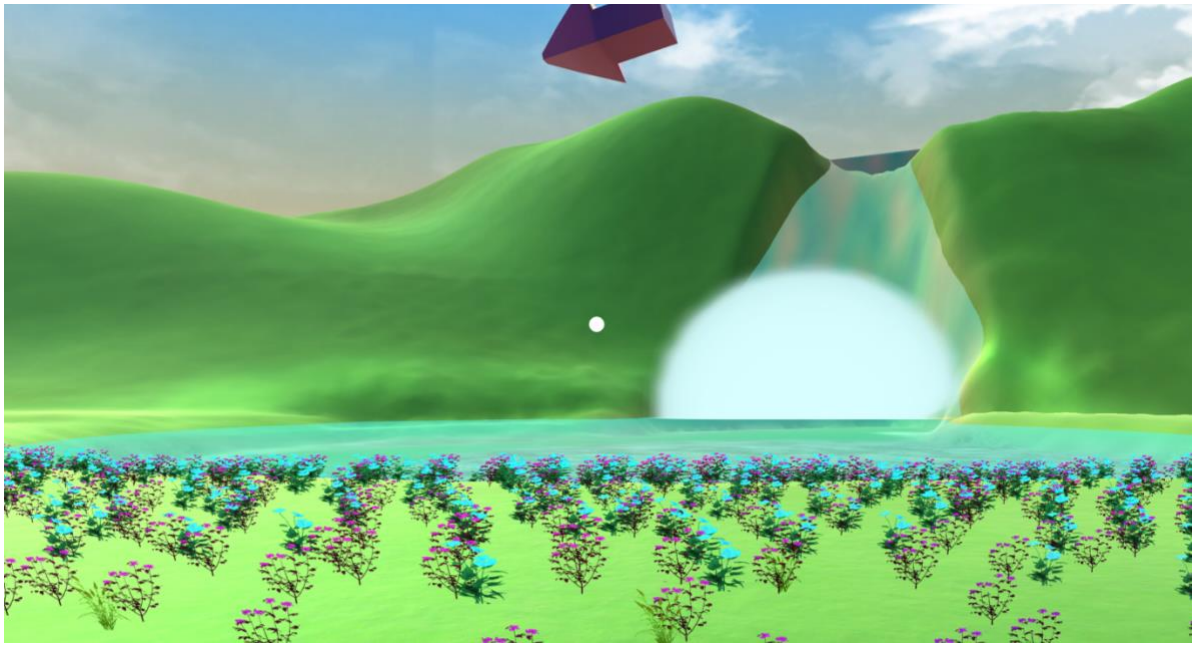

Figure 12. Image of the pond and waterfall in the forest world. This is the location where the therapist avatar takes their client during the human subject trials.

Next, above the waterfall is another pond with a view of the majority of the rest of the forest world. As seen from this location, the scene has a variety of different elevation changes and places to explore. While simple in overall structure, several nooks, clearings, and small details provide opportunities for clients to find a place to their liking. In addition, a slow ripple effect was coded to add some movement and realism to this pond.

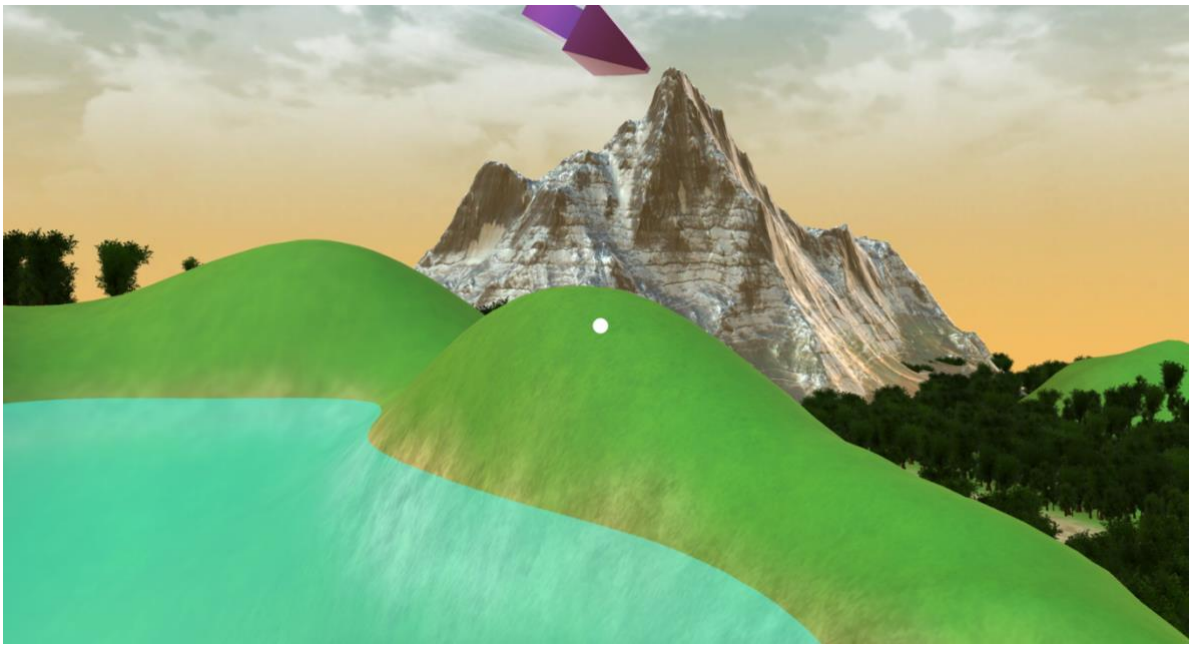

Figure 13. Image of the upper pond in the forest world with view of mountain and other areas.

As mentioned before, the therapist avatar guides the client to a space near the waterfall. The intended use for this environment is to initially allow the client to explore the space as they see fit. Once they sufficiently explored, the counselor can ask the client to walk together with them to a space where they feel comfortable. The client then picks the space to their liking and the two of them settle down together side by side. While the side by side orientation is not required, in this case it adds a sense of partnership and a feeling of going on a journey together. This idea is analogous to the building of a therapeutic alliance, a working relationship, and a partnership towards healing. For some the face to face orientation can feel confrontational and in other remote psychotherapy systems such as videoconferencing sessions, it is the only option for counseling. This free, open world concept gives counselors and clients the ability to experiment what works best for them together.

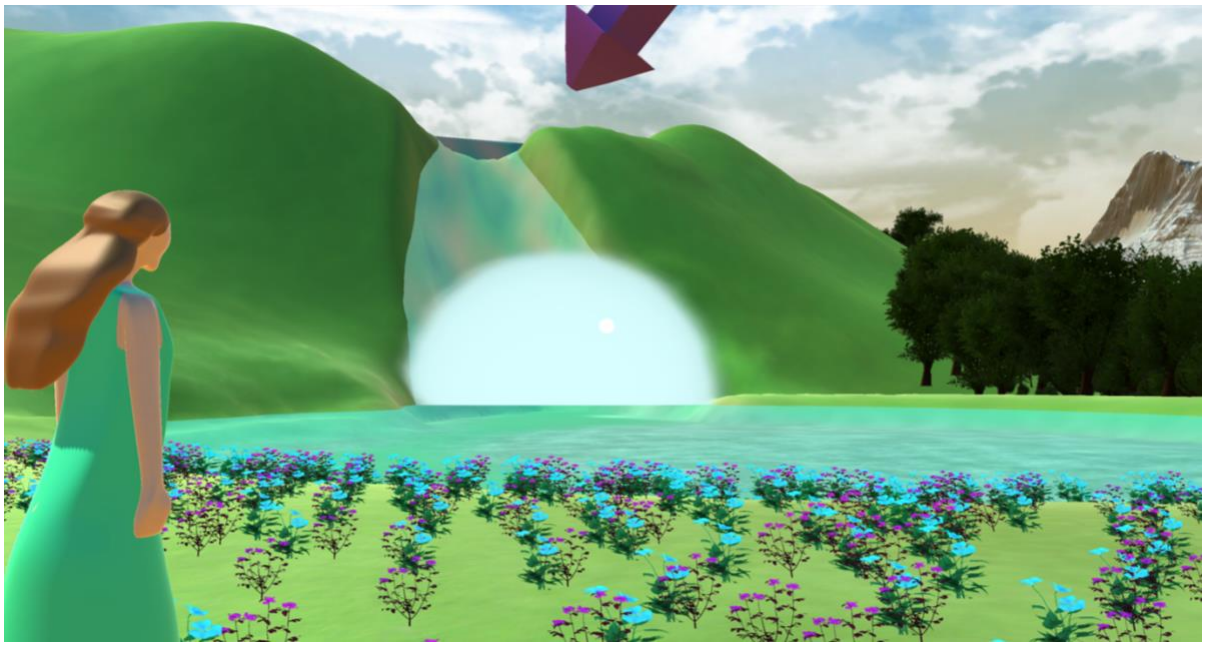

Figure 14. First person view of the client talking alongside their therapist during a counseling session.

Overall, the forest world is intended to be a free flowing open world space that gives client the agency to decide their preferred setting, excites exploration and a sense of journey, and gives clients a calm soothing space to transport to for a counseling session. The space is inspired by nature and forest therapy, fantasy elements, exploration, and the beauty of the natural world. With future development to add more details, artistry, and increased interactivity, this space can truly provide an amazingly restorative environment that may seem completely inaccessible to those using current remote psychotherapy options. In addition, adding elements from other climates and building on the open world concept can increase the sense of wonder, exploration, and client agency in the future.

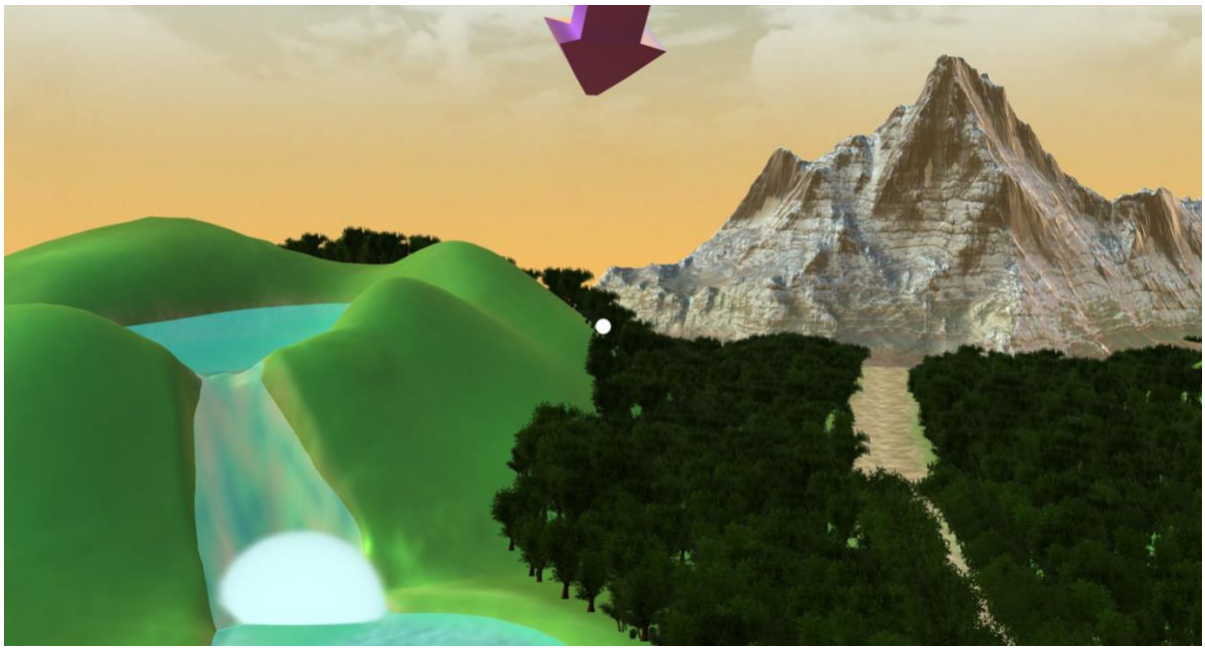

Figure 15. Overhead view of the back portion of the forest world environment.

Log Cabin

The purpose of the log cabin is to provide an indoor alternative to the forest world that still meets the characteristics of restorative environments. Restorative environments feel safe and act as a refuge from the stressors of the outside world. They are soothing spaces that let people feel comfortable enough to open up, a key ingredient to therapeutic healing. Aspects of the design that are intended to give this space a comforting feeling are large windows for a connection to nature, a crackling fireplace to display a warm feeling, and comfortable furniture. Fireplaces or hearths have long been associated with comfort, home, and healing. In Greek mythology, Hestia, the goddess of the hearth is the representation of warmth, family, and home. On cold winter days, fireplaces provide warm and comfort from the outside world and can remind people of being cozy on a couch with a large blanket.

Figure 16. Front view of the inside of the log cabin environment.

The large windows are essential for a connection to nature. The windows give the space the impression of being larger and allow clients to still feel the effects of nature while being indoors.

Figure 17. Side view of the inside of the log cabin environment that shows the large windows.

Another aspect of the design was the development of an outside view of the log cabin as part of the scene selector scene. Clients can walk up to the front door of the cabin and are transported to the inside. The choice to make the scene selection an actual 3D realistic log cabin in contrast to a scene selection drop down menu for example is to give clients a better feeling of presence. They actually feel like they are walking into the log cabin rather than choosing it from a list of virtual environment options.

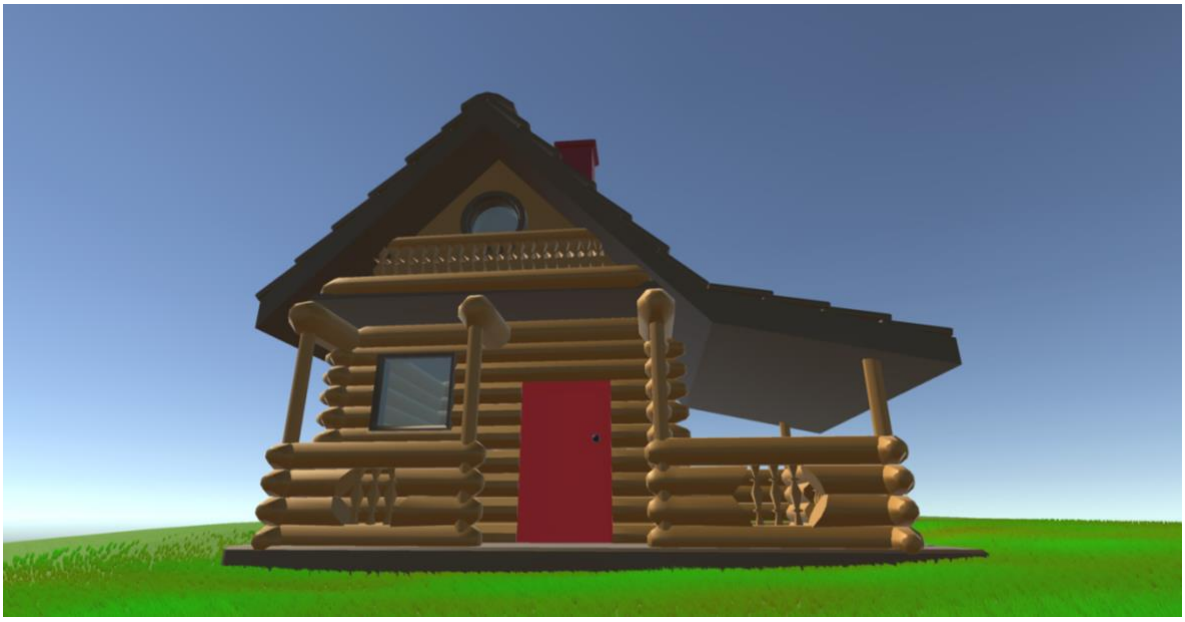

Figure 18. Outside view of the log cabin environment that is present in the scene selector scene.

Freud Therapist Office

The third virtual environment that was developed was the therapist office inspired by Sigmund Freud. As part of this research, the researcher was fortunate to be able to go to Vienna, Austria for a History of Psychology course through the University of Kansas. While there, the class toured Sigmund Freud's therapist office and learned how Freud designed his office space to service his counseling sessions. Freud liked to use dark, muted tones to instill a sense of calmness. He also

covered his walls with books, framed pictures, and awards to show clients his expertise and build legitimacy and trust. Finally, Freud liked to use a large, comfortable couch, in which he asked his clients to lay on their back. This dynamic is used extensively in media as a classic representation of therapy.

For the virtual design inspired by Freud's office, the same principles were used. However, they were adapted to be more suitable for this application. This office kept the comfortable furniture, muted tones, and large bookcases. However, instead of framed images of awards, scientific articles, and other images intended to show Freud's expertise, the image on the walls in this room are all related to the key aspects of VR remote psychotherapy and pay homage to psychology leaders. Examples of the images include images of the initial designs of VR headsets, EEG diagrams, and portraits of famous psychologists. Other images are related to the inspection of this therapy system including images of the University of Kansas buildings where the idea was formulated. Some items in the therapist office include a large rug, plants, and a tabletop bust of Freud. The overall intension of this environment is to give clients an option to have a more traditional counseling session in a cozy and comfortable environment. Clients are intended to lay back on the couch just like Freud asked his clients to do. Further development of this environment could allow counselors to customize their own therapist space with their own personal images. They could add images with their own awards, licenses, and other images that show their expertise and philosophy.

Figure 19. Front view of the Freud therapist office.

One aspect of Freud's office is that nearly all the walls were covered in pictures. Figure X shows a side view emphasizing covering the entire walls with psychology, neuroscience, and virtual reality related images.

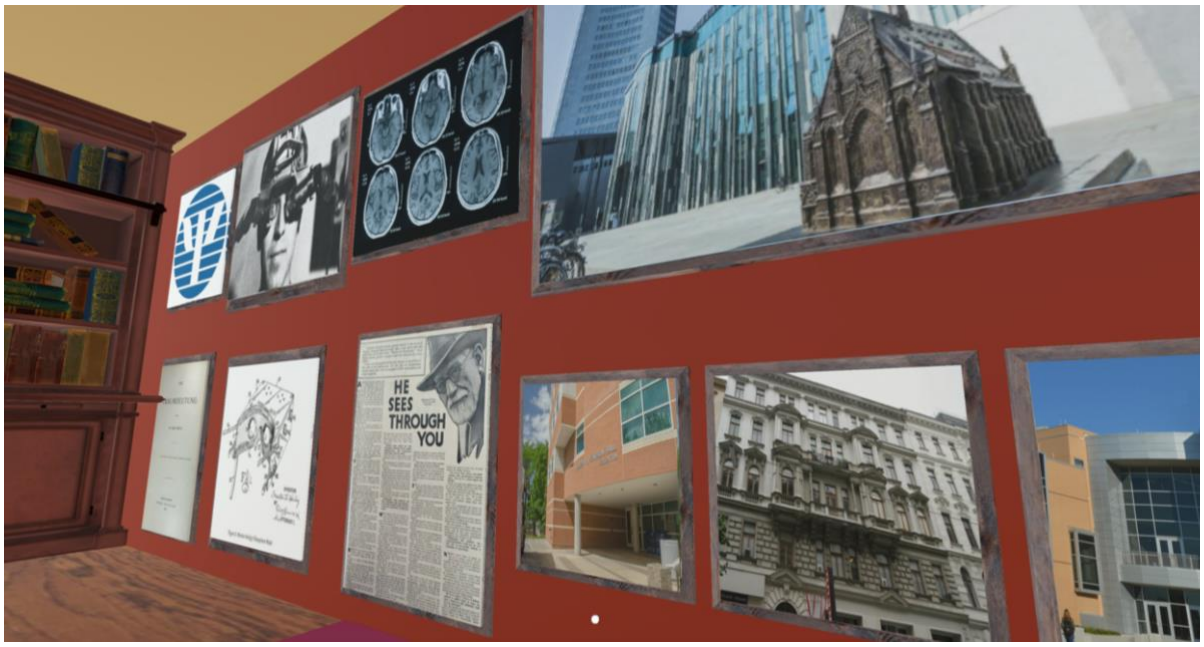

Figure 20. Side view of the Freud therapist office.

Future developments to the Freud therapist office include giving the user a body, so that it looks more realistic when clients are laying on the bed. In other environments, it's not as noticeable in first person view that the person does not have a body, however the appearance of arms and legs while on the couch is much more essential in this environment. It would also be helpful to allow clients to customize how their avatars look. Giving clients the option to present themselves in they would like, gives them another form of agency over their counseling sessions [127].

Figure 21. Client view in the Freud therapist office where they are laying on their back.

Music and Sound Effects

In addition to the visual elements in a virtual environment, the auditory component of the environment plays a large role in building immersion and comfort in users. Music can inspire a wide variety of emotions including happiness, sadness, excitement, and calmness. Soft background music can be comforting and can help make an environment feel safe. In this case, soft instrumental music is used throughout the scenes and gives the environment a more mystical

feel. In addition to music, sound effects are necessary to make a virtual environment feel more real and thus, inspire immersion. In forest world, rushing water, rustling leaves, and blowing wind are included spatially throughout the environment. For example, when clients are near the waterfall, they can hear the water softly splashing on to the pond, but when they move away from that area, they can no longer hear it. In the log cabin, fire crackling sounds are used to make the fireplace feel more real.

Movement and Physics

In both the log cabin and Freud therapist office, clients are stationary, placed in comfortable seating to conduct their counseling sessions. However, in the forest world, clients are allowed to move freely and explore the space. This is essential to giving clients control over their counseling sessions, allowing them to choose where they would conduct sessions. It also frees clients up to explore, experiment, and examine new things, building excitement and mysticism. In fact, because the forest world is mystical and magical in nature, clients are able to fly around through the scene, towering over the environment or weaving through the trees. Clients are given instructions to move in the following way: 1. In order to start moving, they must look directly up at the sky, 2. While moving, they will travel in whatever direction they are facing (meaning they move with their eyes), and 3. To stop, they must look directly down at the ground. This movement structure was used for simplicity, only three simple steps to movement, and for increased immersion in mobile VR, no need for a controller. One limitation to this set up is that the client cannot travel downwards at a steep angle without stopping. However, with some practice, users typically learn to move freely around the environment quickly. The speed of the movement also had to be coded deliberately in Unity3D. For simplicity, while moving, the client always move at the same pace.

Determining the right speed of movement took trial and error with test users to find a balance between being too slow that it is frustrating and too fast that it is disorienting.

Physics in the environment were designed to be free flowing and mystical. Gravity does not exist for users, but does for other elements, such as the waterfall. Users are also able to glide within the trees. Object rigidity was suppressed in favor of a freer flowing, forgiving environment. Users can pass through or between objects. Future developments can experiment with more object rigidity to increase the immersion of the scene. However, more testing would need to done to determine if this change makes it more difficult for users to move around in tightly packed areas.

Future Developments

Future developments to the overall virtual environments include continuing to build upon the open world concept to give clients more variety in their choices, working to seamlessly string together different environments so that clients can move between them freely, and experimenting with color, audio, and movement changes. In addition to a forest world, natural worlds from other climates could help give clients other alternatives. Some examples of future outdoor environments include a coastal beach or island, winter wonderland, and desert oasis. Adding different climates could provide a twofold benefit: clients could pick the environment more familiar to them or could pick the environment that they could never imagine being able to see in real life. It is important to make sure with added environments that the free flowing movement is preserved. Giving clients the opportunity to explore before settling down into the environment of their choosing helps build excitement and keeps them in control of their experience. Other future developments include first person body avatars, more movement in the indoor scenes, and a more realistic scene selector scene.

Therapist Avatars

The next key component to the VR remote psychotherapy system design is the use of therapist avatars. The purpose of therapist avatars is to serve as a representation of the counselor in the virtual space. One of the goals of the VR remote psychotherapy system was to provide an alternative counseling option for clients who find the face-to-face nature of videoconferencing based psychotherapy too uncomfortable. Thus, for these populations, it would not make sense to incorporate video of the counselors' faces into the system. However, a virtual environment without any visual of the counselor would make communication between counselors and clients disconcerting. The voice of the counselor in VR would sound as if it was coming from the sky and for the client it would feel like talking into a void. Therefore, some visual representation of the counselor in the virtual environment was necessary. Avatars are commonly used in video games and VR applications. They refer to virtual characters that embody, in this case, the counselor in the virtual space with the VR user. In VR psychotherapy applications utilizing avatars, clients will communicate with their counselors through talking to the avatar and counselors will act as if they are speaking from the mouth of the character they are embodying.

Therapist avatars were designed to meet certain criteria necessary to embody character representations of positive therapist characteristics. Successful designs of therapist avatars would allow therapists to build rapport more quickly and instill trust. Certain attributes in counselors are found to positively contribute to building the therapeutic alliance. Some examples of these attributes are being flexible, experienced, honest, respectful, trustworthy, confident, interested, alert, friendly, warm, and open [115]. Different clients look for different things from their counselors, however some common themes arise across most clients. These common themes include expertness and wisdom, compassion and empathy, similarity and liking, and genuineness

and trustworthiness. The expertness and wisdom theme refers to clients that value counselors who they believe can give them good advice and help them solve problems rationally. The compassion and empathy theme refers to clients that value counselors who will listen to them, understand them, and treat them with kindness. The similarity and liking theme refers to clients who value counselors that they feel they can relate to, have similar life experiences to them, and can talk to them like a friend. The genuineness and trustworthiness theme refers to clients that value counselors who they feel are honest, someone they can trust deeply, and someone with which they can be vulnerable. Typically, clients tend to value at least one of these common themes when they are looking for counselors, and up to as many as all of them equally. Design choices for the avatars were intended to visually represent these characteristics to clients [115].

Software and Development Pipeline

Two therapist avatars were designed for use in the prototype system. Therapist avatars were designed by artist and counseling psychology PhD student at the University of Kansas, Kaylie Lyons Ridgeway. Initial drawings of the characters were done in both a front and side view. Using the front and side view, the avatars were created in Autodesk Maya. Creation in Autodesk Maya involved sculpting the 3D structure using the drawings as guideposts, UV shelling the model for texturing, and creating the UV map for texturing in Adobe Photoshop. Once the avatars were created in Autodesk Maya, they were then saved into Unity3D and automatically imported as assets. Software used in this project was selected because of the availability of programs for free and the cross compatibility of the programs with Unity3D.

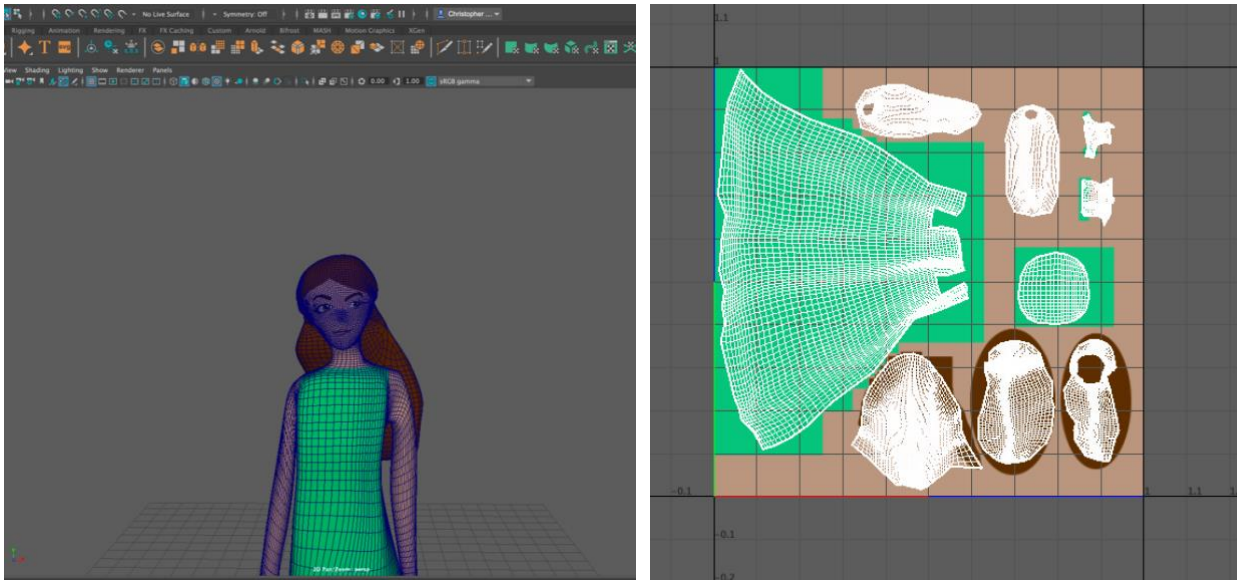

Figure 22. Example of therapist avatar being created in Autodesk Maya and view of the UV shell created for texturing. The image with the textures on the UV map was imported from Adobe photoshop.

Jungian Archetypes and Key Therapist Characteristics

The specific designs for the therapist avatars were inspired by Carl Jung's archetypal theory or Jungian archetypes. In Jung's philosophy, the conscious mind emerged from the unconscious mind. He theorized that the human psyche was comprised of consciousness, personal unconscious, and collective unconscious with collective unconscious referring to ideas, concepts, or events that are unconsciously shared across all humans [118]. In Jung's philosophy archetypes operated as the components of that collective unconscious, which he believed to be the building blocks to all human psychology. Jung proposed four major archetypes that played a role in building a person's personality: The Persona, The Shadow, The Anima or Animus, and The Self. The Persona refers to how we present ourselves to the world. The Shadow refers to the basic instincts present in our unconscious mind. The Anima or Animus refers to the "true self". The Self refers to the unified unconsciousness and consciousness of an individual. Different combinations of these four major

archetypes form the basis to Jung's archetypal figures [118], [119]. Contemporary ideas based on Jungian archetypal theory developed 12 common archetypes that are widely recognized in entertainment media, branding, and art. The 12 common archetypes are as follows: The Innocent, 2. The Everyman, 3. The Hero, 4. The Caregiver, 5. The Explorer, 6. The Rebel, 7. The Lover, 8. The Creator, 9. The Jester, 10. The Sage, 11. The Magician, and 12. The Ruler. Each of these common archetypes have associated traits that a widely recognizable and commonly used as tropes in media [120]. **Table X** outlines the 12 common archetypes and their associated traits.

Table 3. The 12 common archetypes and their associated traits.

12 Common Archetypes	Associated Traits
Innocent	Naïve, optimistic, dreamer
Everyman	Down to earth, empathetic, realist
Hero	Courage, strong, skillful
Caregiver/Healer	Compassionate, generous, caring
Explorer	Ambitious, individualistic, adventure seeker
Rebel	Disruptor, revolutionary, misfit
Lover	Passionate, committed, appreciative
Creator	Creative, imaginative, artistic
Jester	Joyful, jokester, funny
Sage	Wise, intelligent, expert, teacher
Magician	Visionary, inventor, charismatic
Ruler	Leader, responsible, boss

While little psychological evidence suggests that the 12 common archetypes form the basis of the origins of human personality, these 12 archetypes are widely recognized in culture. Characters using these tropes are present all across the most popular books, movies, television shows, and even celebrity figures. For example, common representations of the sage include Gandalf from the Lord of the Rings and Albus Dumbledore from the Harry Potter series. For the purposes of use in the VR psychotherapy system, these archetypes helped identify character tropes that clients could immediately recognize. For example, a client valuing a wise or expert counselor would

immediately be able to recognize the parallel with the sage and thus may be drawn to choose the sage or wizard avatar for the counselor. Thus, designs for therapist avatars were chosen from the common archetypes that contained associated character traits that are valued by clients seeking therapy. To begin, two therapist avatars were chosen and developed: A Wizard (or Sage) Avatar and a Woman Healer (or Caregiver) Avatar.

Wizard Avatar

The wizard avatar was the first avatar developed for the VR psychotherapy system. It was chosen as a physical representation of the sage archetype and intended to represent a counselor who is expert, knowledgeable, and gives good advice. Additionally, the wizard is also a fantastical character, which matches with the aura of the virtual environments in the system. The wizard avatar went through two iterations, the first was a cartoon wizard developed by Christopher Tacca and the final avatar was designed by Kaylie Ridgeway Lyons. For the purposes of the prototype, a modified version of the initial design was used in the studies. The new avatar design is currently in development. Image of the conceptual design of the new avatar and the virtual avatar used in the prototype are seen in **Figure 23**.

Figure 23. The conceptual design of the updated wizard avatar (left) and the current wizard avatar used in prototyping (right).

Woman Healer Avatar

The second avatar developed for the VR psychotherapy system is the woman healer. It was intended to provide both a female alternative to the male wizard and also instill a sense of caring and compassion in clients. The woman healer was designed by Kaylie Lyons Ridgeway and developed virtually by Christopher Tacca. Images of the conceptual design and the virtual avatar used in the prototype are shown in **Figure 24**.

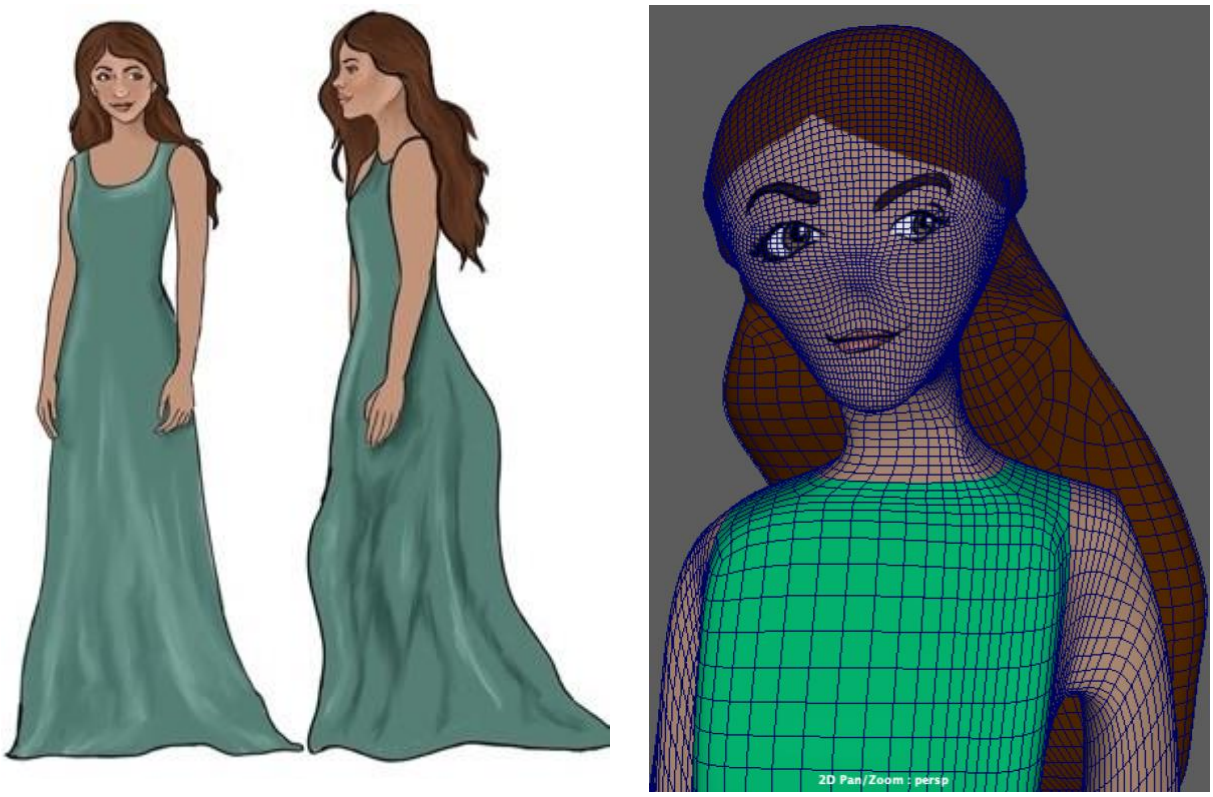

Figure 24. The conceptual design of the woman healer avatar (left) and a headshot of the woman healer avatar used in prototyping (right).

Future Developments

Future developments to the therapist avatars include updating the current avatars to portray the designs more accurately by Kaylie Lyons Ridgeway, developing new therapist avatars based on the other Jungian archetypes such as the explorer, creator, and the everyman, and develop avatars to represent more accurately the cultural, racial, and gender diversity of the counselor population.

EEG Neurofeedback System

The purpose of this section is to outline the decision making process for the live display of the EEG signal. We will focus on the design of the prototype used in the assessment of the VR psychotherapy system, because the potential designs of the neurofeedback system and therapies interface were discussed in a previous section. The goals for the design of the live EEG display

were to give counselors the basic information that they need to understand their clients' brain activity levels and basic emotions in real time and to keep the display as simple as possible so that counselors would not be distracted from their main duties as therapists.

Software

MATLAB software was used to create the live display of the EEG signal. It was chosen because of familiarity with the researcher and because there are existing open source packages that help extract the raw signal from the EEG headset to MATLAB. Two different methods were used to process the data from the EEG headset in MATLAB.

Live Display

The first method of processing the EEG data was for the initial prototype that uses the Neurosky Mindwave Mobile 2 headset. The Neurosky researcher package was purchased in order to access the raw data. The display was created using the given functions from the Neurosky researcher package and using MATLAB's guided user interface package. This method was beneficial because it was very easy to process and display live signals into the guided user interface (GUI). However, it was very limited by the given functions from the Neurosky researcher package. For example, data from the headset would be pre-filtered into the different frequency bands such as alpha, beta, gamma, and delta, not allowing for the researcher to determine frequency boundaries for themselves. In addition, Neurosky included values for attention and meditation, but did not include any calculations for where those values came from. One design choice for the live display of the EEG data was to make the display signals customizable, meaning that counselors would be able to choose which frequency bands they would like to see during the session, so they could choose to have displayed the raw signal and the frequency spectrum (alpha, beta, gamma, delta, and theta

waves) in whatever combination they preferred. The live display of the EEG data using this method is shown below in **Figure 25**.

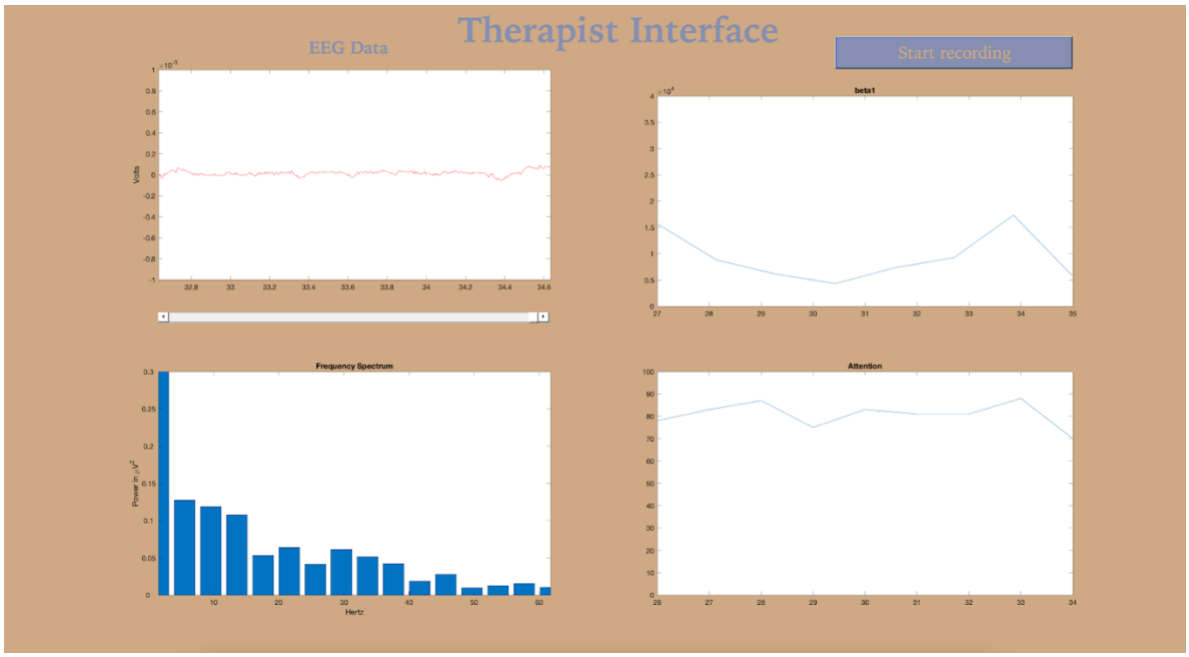

Figure 25. The EEG live display developed using the Neurosky researcher tools for MATLAB.

The second method for processing the EEG live data was developed for the MUSE 2 headband. The raw data from the headset was connected to the computer in MATLAB using the application developed by the University of Victoria (Krigolson Lab) in Canada. This application checked the raw data from the signals and converted it into a usable format to be live processed in MATLAB. Thus, data processing of the live signal was completely customized for use in the VR psychotherapy system. In MATLAB the live display was designed and developed using MATLAB's app developer platform. In this platform the signal was coded, filtered and live processed to be displayed on several different axis that would show the raw signal as well as the various different frequency bands. For the purposes of the prototype, the live display showed the raw signal, the frequency spectrum, the alpha waves, the beta waves, and the gamma waves. The

live display of the MUSE to EEG data is shown in **Figure 26**. Future developments will be make the live display more customizable for counselors and more appealing to users.

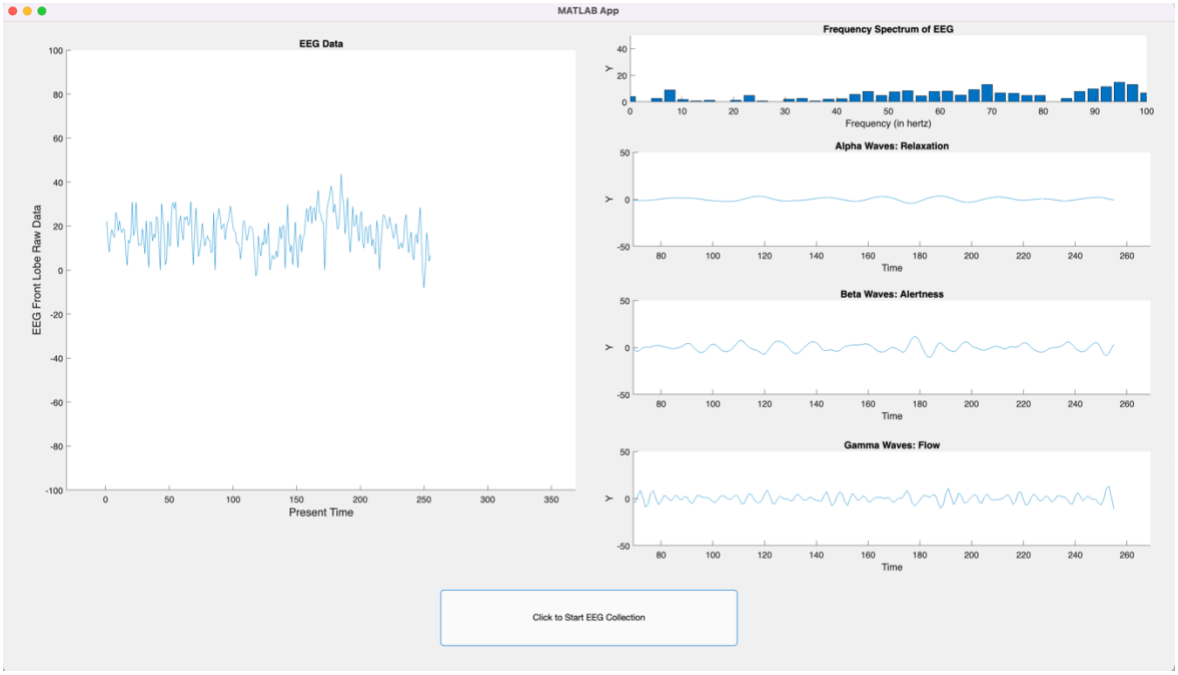

Figure 26. The live display of the EEG signal in MATLAB using the MUSE headband.

Conclusion

The VR remote psychotherapy system for isolated populations was deliberately developed based on the principles of common factors theory. Each component of the system was implemented to provide counselors with the necessary tools that they would need to conduct effective psychotherapy sessions with clients remotely. The major components of the design and development include the choice of hardware and software for the system, the design of virtual environments, the therapist avatars, and the neurofeedback system. For each of these components, cost, effectiveness, adherence to the common factors (such as the principles of restorative environments and the keys to fostering a therapeutic alliance) and ease of use, were used as benchmarks for design decisions. For example, the virtual environments were designed based on

the principles of healing environments and nature therapy and were intended to give clients a space where they feel safe, comfortable, and open to being vulnerable. The therapist avatars were designed to represent key characteristics that clients look for in their counselors and characteristics that have been associated with forming a stronger therapeutic alliance. The EEG neurofeedback system was designed to give counselors the tools they needed to effectively communicate remotely with their clients, despite the distance across which they are communicating and the lack of visuals of the clients due to the virtual reality modality. Chapters 4 and 5 will discuss how the researchers assessed this novel VR psychotherapy system for its effectiveness, for both counselors and clients.

CHAPTER 4: Determine the functionality and usability of the novel common factors based VR therapy system for therapists

Abstract

Since the COVID-19 pandemic, more than 40% of the population suffer from some form of mental illness and more than 40% of them receive no treatment for their mental illness whatsoever [1]. Several barriers to treatment include stigma, prohibitive cost, and a feeling that treatment is inaccessible to them [8], [10]. For rural, psychologically isolated, and poorer communities this gap in treatment to need is greater with these populations receiving counseling at lower rates than their counterparts [12]. A need for an effective and accessible remote treatment of depression is present. A novel remote VR psychotherapy system developed at the University of Kansas is assessed for its functionality and usability for therapists. Observing counselors rated the counseling system as well or better than neutral therapy for its depth, smoothness, positivity, and arousal (Session Evaluation Questionnaire), perceived restorativeness, client reactions, and presence. Future work will assess the functionality and usability of the novel VR therapy system for patients.

Keywords: Virtual Reality, EEG, Remote Psychotherapy, Common Factors Theory

Introduction

Mental illnesses affect millions of people in the United States and around the world. Since the COVID-19 pandemic, more than 40% of the population suffer from some form of mental illness. In addition, more than 40% of those people receive no form of treatment whatsoever for their conditions [1]. Several barriers to treatment include stigma, prohibitive cost, and a feeling that

treatment is inaccessible to them [8], [10]. For rural, psychologically isolated, and poorer communities this gap in treatment to need is greater with these populations receiving counseling at lower rates than their counterparts. For rural populations, distance to the nearest therapist office, lack of overall resources, and stigma all contribute to this disparity [11], [14], [20]. For psychology isolated populations, getting out of bed in the morning, going out into public, and seeing a therapist in person can be too anxiety inducing, meaning the act of receiving treatment is a barrier in itself to treatment. In 2020 and 2021, the COVID-19 pandemic made in person counseling impossible necessitating remote psychotherapy alternatives. Solutions such as videoconferencing therapy (Zoom, Zoom Pro, Doxy.me), online therapy companies (Betterhelp, Talkspace), and phone or text based therapy were used at a much higher rate. Before the pandemic less than 30% of mental healthcare professionals included a form of telepsychology into their practice, however since 2020, the number of mental healthcare professionals who had used these technologies in their practice increased to 98% [22]. For many, these solutions have provided a necessary lifeline during a difficult, grief ridden, and stressful time.

However, for some, particularly the isolated populations described earlier, the current solutions do not facilitate the best environment for therapeutic healing. According to common factors theory, several factors need to be in place for therapeutic healing to occur. Two of these factors include the therapeutic alliance, the ability to form a working partnership between counselor and client, and the therapeutic environment, a setting for therapy that is comforting, safe, and allows the client to be vulnerable. Current remote options require users to conduct counseling sessions where they are. While convenient, for those who are in stressful or triggering environments, conducting a counseling session in the same space as all these surrounding negative stimuli can be very difficult. In addition, over distance some communication can be lost and the ability for counselors to read

nonverbal cues and build rapport can be more difficult [3], [4], [92], [93], [95], [96]. A novel VR psychotherapy system that utilizes EEG technology is proposed as a potential solution to these limitations. VR can build presence in its users allowing for developers to "transport" clients to environments that feel safe, comfortable, and allow them to be vulnerable. In addition, the EEG live neurofeedback can help give therapist an idea into their clients' basic emotions during counseling sessions, giving them the tools that they need to communication more deeply, build rapport, and form a therapeutic alliance.

In this study, the novel VR psychotherapy system is assessed for its usability and functionality for counselors [128]. A mock counseling session was conducted and critically analyzed by observing counselors to assess whether the VR therapy system could potentially be a valuable tool for counseling.

Methods

The purpose of this study is to determine a proof of concept of the usability and functionality of the novel common factors based EEG-enabled VR psychotherapy system for therapists.

Experimental Design

The study consisted of a single 45 – 60 minute mock counseling analog for a solution-focused counseling session for the treatment of depressive symptoms using the novel VR system. A licensed psychologist played the role of the therapist, and an actor played the role of the client who is seeking counseling for depressive symptoms following the death of his friend. The therapy script used in the session was developed as a standard representation of the intended use of the proposed therapy system. During the session, the counselor was on the other side of the room from the client facing in the other direction to mimic the remote aspect of the treatment. The client

was seated at the front of the room wearing the virtual reality (VR) headset and electroencephalography (EEG) headset. In the room with client and therapist, 21 counselors in training observed the session. At the front of the classroom, a projection of the therapist interface was displayed so that the observing counselors could view what the therapist was seeing during the session. Immediately following the therapy session, the observing counselors were asked to critically analyze the counseling session and the merits of the therapy system across four metrics described below.

Participants

21 counselors in training acted as the participants for this study. The counselors were chosen from a graduate level course in the school of Educational Psychology at the University of Kansas. In this course, students are asked to critically analyze various different counseling technique and therapy methods. All had previous experience viewing counseling session critically.

Measures

The therapy session was analyzed across four study metrics: the Client Reactions System (CRS), Perceived Restorativeness Scale (PRS), Session Evaluation Questionnaire (SEQ), and Presence Questionnaire (PQ). Surveys were given to subjects immediately following the session and results were recorded anonymously through Qualtrics. The purpose of the CRS is to assess the basic reactions from the session and quantify the general feeling of the client following the session. It has been found that in successful sessions client reactions are more related to therapist intentions than in unsuccessful sessions. In addition, positive client reactions scored higher in client helpfulness ratings than negative client reactions. In this context, the CRS is used a way for the observing counselors to quantify their overall assessment of the quality of the therapy session

[121]. The PRS is used as a metric to analyze the environment of the therapy system across the categories of restorative environments. It has a Cronbach's alpha coefficient of greater than 0.75 and has been found to be a valid measure of natural and built environments. Through this metric, counselors are asked to analyze the environment of the therapy session, both physical and virtual, to assess how suitable the environment is for psychotherapy [116]. The SEQ is a standard measure that is used extensively to analyze therapy session and is considered a valid metric to quantify the therapeutic alliance. The SEQ quantifies sessions across four indexes: Depth, Smoothness, Positivity, and Arousal. It has been found that positive evaluations in the SEQ are related to early client working alliance ratings and positive scores in depth and smoothness are significantly correlated with a strong working alliance. Smoothness has been found to be important in establishing a positive working alliance and depth has been found to be important in maintaining a working alliance throughout [40], [122], [129]. In this study, the SEQ will be used to assess how well the therapy system facilitated a therapeutic alliance during the session. The PQ is a standard metric used to analyze VR experiences. The purpose of this metric is to quantify how well the virtual environments instilled a sense of presence in the users. It has a Cronbach's alpha coefficient of 0.91 and is considered a valid measure of the quality of immersion in VR experiences [123]. In this context, the observing counselors assessed how well the VR elements in the system built presence and immersion for the client during the session.

VR Therapy Setup and Environment

The experimental setup mimicked the potential use of the therapy system in practice. The overall setup consisted of four main parts: 1. Connection Between Counselor and Client, 2. Counselor Interface and Setup, 3. Client Setup, and 4. Observants' View.

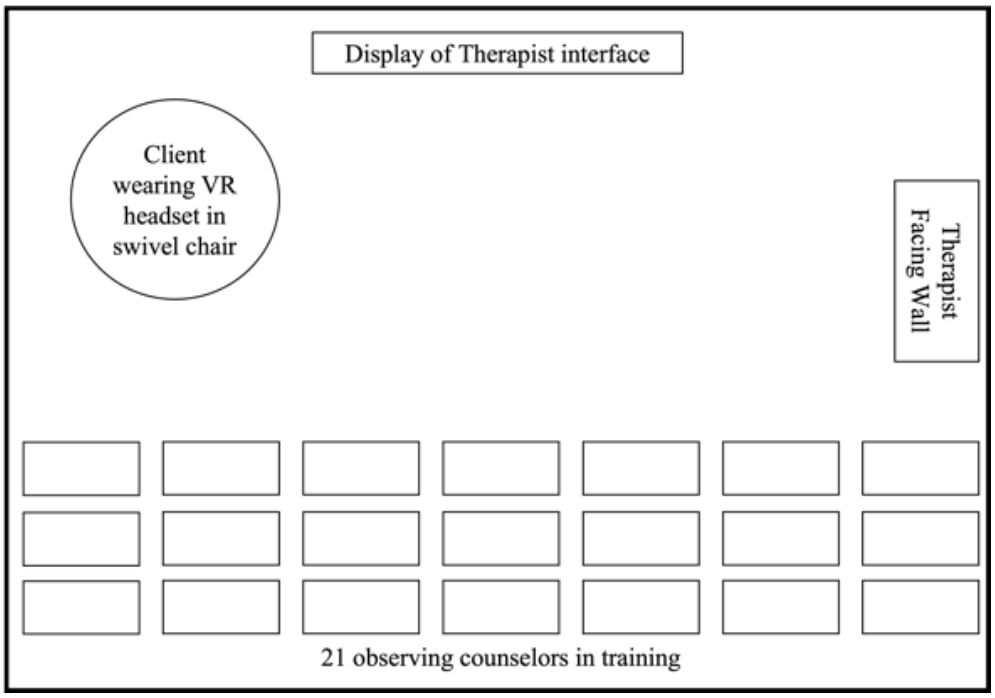

Figure 27. The room setup for the study. The 21 observing counselors could view the therapist view from the large projector at the front of the classroom.

Connection Between Counselor and Client

The audio connection for the mock session between counselor and client was facilitated using Zoom Videoconferencing. The client was connected to Zoom Audio on the phone used in the session that also contained the VR application and listened to the audio through wireless earphones. The counselor was connected on Zoom on the laptop that also displayed the therapist interface described in more detail below.

Client Setup

For the session, the client sat at the front of the classroom wearing both the EEG (Mindwave Mobile 2) and mobile VR (Hamswan SC-Y005 3D VR Glasses) headsets. In the VR, the client started in the scene selector view, walked towards the portal to the forest world, and entered into the forest world virtual environment. The client's view in VR was from a first person perspective. Once in the forest world, he was met with the avatar for the therapist, which in this case was the woman healer. From that moment forward, the client journeyed with the therapist avatar and followed the therapy protocol as described in the following section.

Figure 28. The client view as he entered the forest world. The therapist in the scene is represented by the woman avatar.

Therapist Interface and Setup

The prototype for the therapist interface in the system consisted of three parts: 1. The Zoom audio connection described above, 2. The live EEG neurofeedback display made in MATLAB, and 3. The live display of the client's view in VR. The client's view in VR was shared to the counselor through Teamviewer by live streaming from the client's phone. The therapist inference was shared to the observants through the Zoom screensharing function.

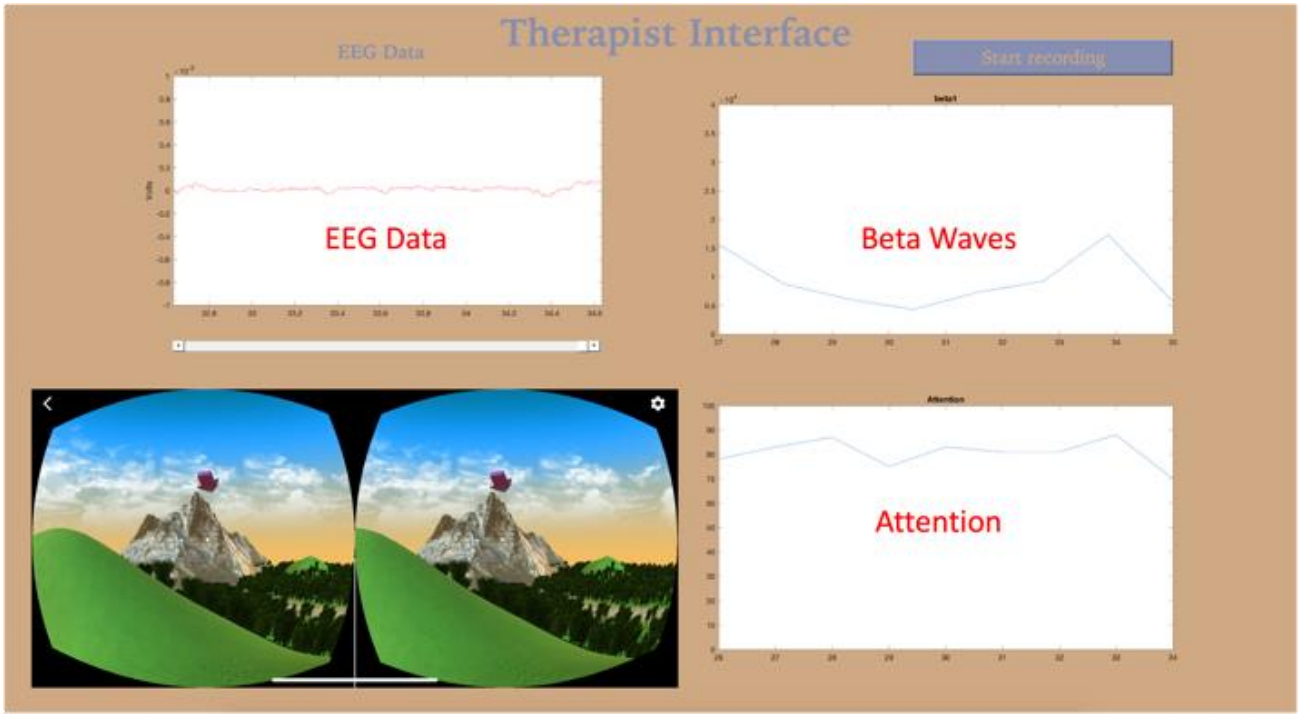

Figure 29. The view of the therapist during the study. The interface included a live view of the client's EEG data and view in VR.

Observers' View

The observants viewed the therapy session from the classroom. In their view, they could observe the client in VR and the therapist interface through a project of the Zoom screen share at the front of the classroom.

Procedure

The procedure for the study can be broken down into three parts: 1. Pre-session introduction, 2. Therapy session, and 3. Post- session Assessment.

Pre- Session Introduction

The subjects were instructed that they would be observing an analog session of a novel therapy system and that following the session they would be given four surveys to critically assess the therapy session for usability and functionality. They were not given any other form of prompting about the therapy system or its potential merits before the session in order to not introduce any bias.

Therapy Session

The mock therapy session was similar to a potential standard use of the proposed therapy system. In this scenario, the client is seeking therapy for the treatment of depressive symptoms as a result of the death of a close friend. The client is a young male in his 20s, who has a history of playing video games and being comfortable in a technological environment. This demographic is representative of a population that is would potentially be suitable for this form of treatment.

The counseling script consisted of as follows: 1. A beginning portion where the counselor asked the client was since the first session and the client described what they had been struggling with, 2. A brief exploration of the space, 3. Then when the client was ready, they began to walk towards the pond together and settle down there for the session, 4. The therapist then asked for the client to expand on his struggles, 5. At a certain point, in the therapy when the therapist noticed a spike in the EEG, she asked the client about it, 6. Using this response, the therapist probed further, 7. This led to the client revealing a deeper truth about what he had been struggling with, 8. Finally, there was an emotional response from the client and he goes off in the distance to explore with the therapist following behind, 9. In the end, there was a brief conclusion and a plan for a further session.

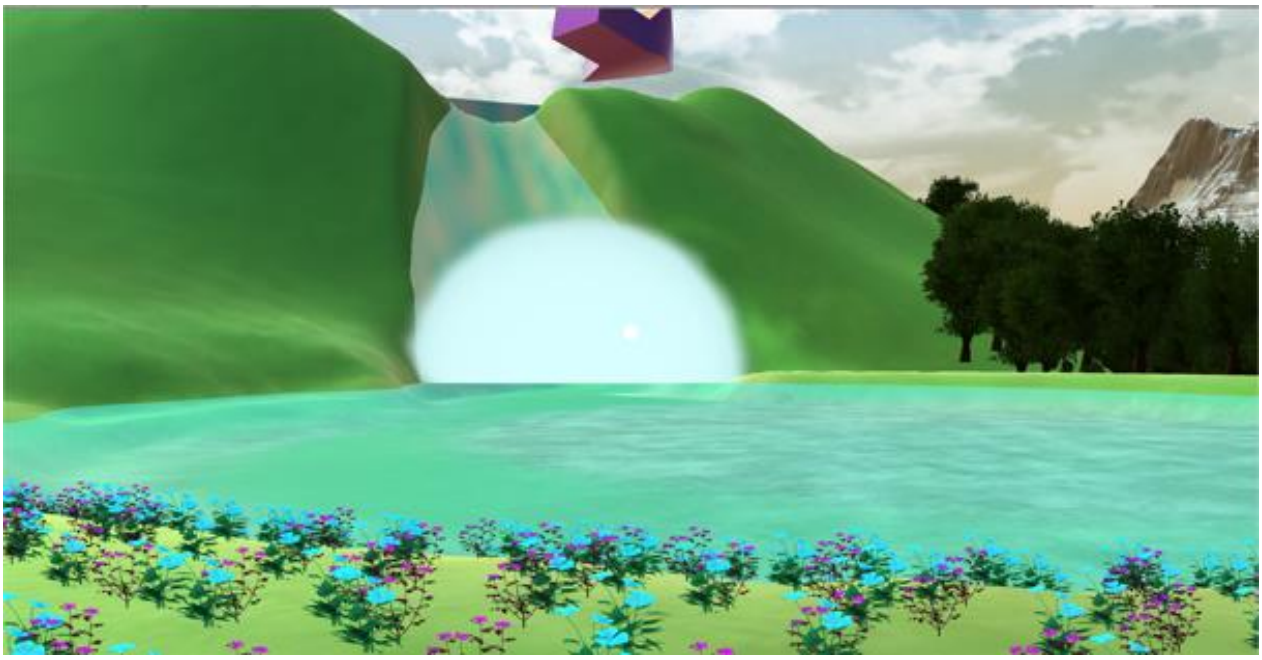

Figure 30. The location in VR where the counselor and client conducted the majority of the therapy session.

Post- Session Assessment

Immediately following the therapy session, the observing counselors in training were asked to complete four study metrics in Qualtrics: 1. Client Reactions System (CRS), 2. Perceived Restorativeness Scale (PRS), 3. The Session Evaluation Questionnaire (SEQ), and 4. The Presence Questionnaire (PQ). The CRS is used to get general reactions to the quality of the session and the overall response from the client. The PRS is used to quantify how well the environment in which the session was conducted (both physically and virtually) facilitated a restorative space conducive to therapy. In this context, the SEQ is used as a way to quantify how well the therapeutic alliance was facilitated during the session. Finally, the PQ was used to quantify how well the virtual environment immersed the client and built presence during the session.

Statistics

The criteria for success in this study is for the therapy system to perform within the standard deviation or above the neutral value for each of the metrics. For the CRS, PRS, and PQ the neutral is 3. For the SEQ, the metric is separated into four indexes: Depth, Smoothness, Positivity, and Arousal. The neutral score for each category is 20.

Results

The four metrics used in this study were intended to characterize how a potential use of this psychotherapy system might address therapists' needs in remote therapy. Across all subjects the mean and standard deviation of the Client Reactions System was 4.24 ± 0.52. This suggests that overall, the observing counselors had a positive reaction to the therapy session. For the Perceived Restorativeness scale, it was 3.85 ± 0.98 suggesting that the observed restorativeness of the

environment both physical and virtual was adequate or positive. For the Presence Questionnaire, it was 3.52 ± 0.78 suggesting that the level of immersion during the VR therapy session was observed to be adequate or positive.

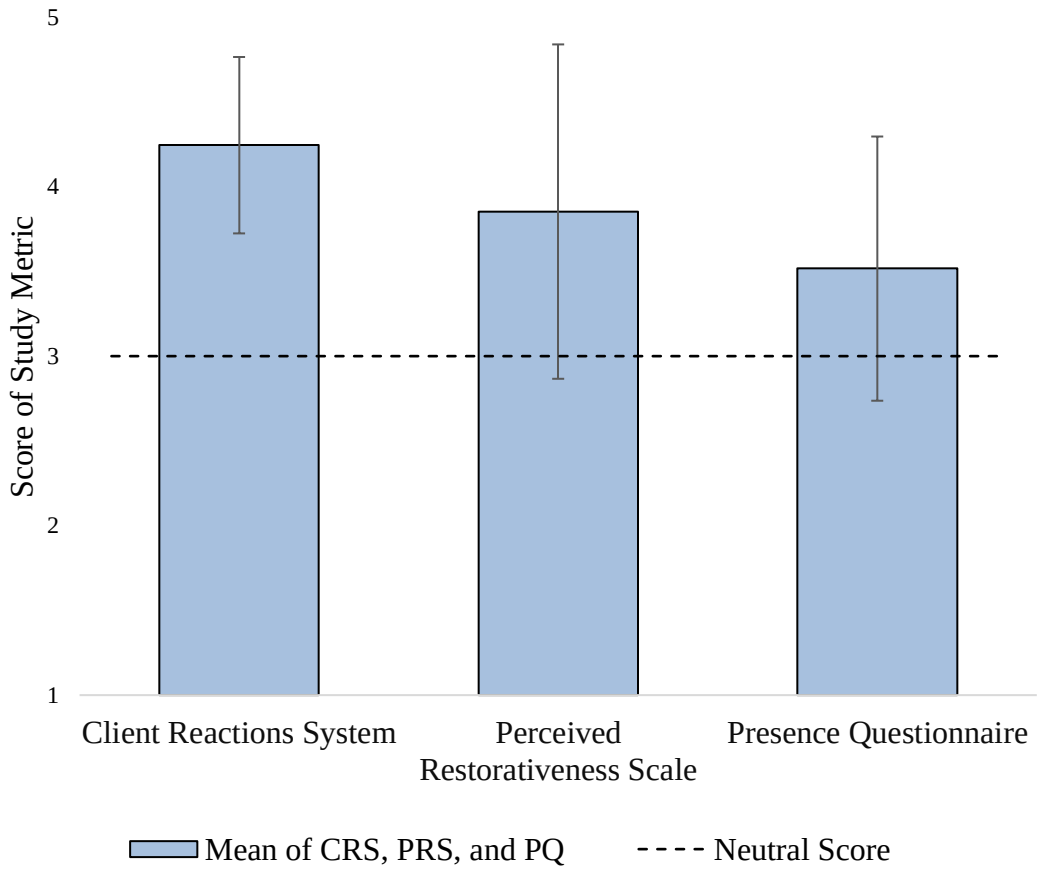

Figure 31. The mean and standard deviation score of the three study metrics: Client Reactions System, Perceived Restorativeness Scale, and Presence Questionnaire.

The Session Evaluation Questionnaire is analyzed across four indexes, which each include five bipolar items and have a total range of scores between 5 and 35. The mean depth score was 29.01 ± 5.57 suggesting that the counselors observed a session that felt relatively deep and meaningful. The mean smoothness score was 22.27 ± 5.97 suggesting that the counselors

observed a session that a slightly above average level of smoothness. The mean positivity score was 25.22 ± 5.78 suggesting that the counselors observed a session that was overall positive. The mean arousal score was 19.61 ± 7.43 suggesting that the counselors observed a session with an average level of arousal.

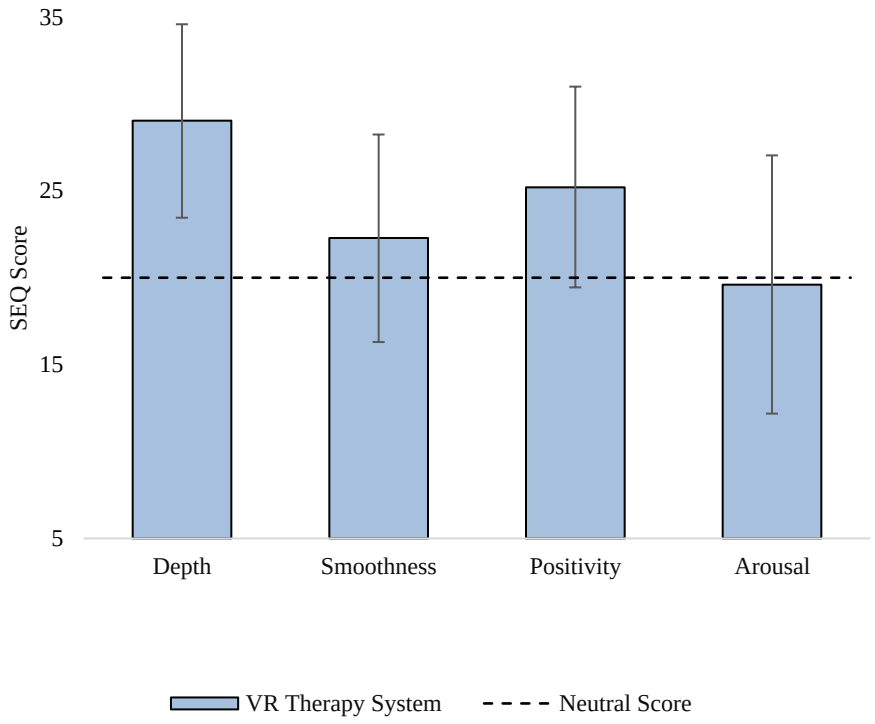

Figure 32. The mean and standard deviation of the indexes of the Session Evaluation Questionnaire.

Discussion

A mock counseling session using the novel VR therapy system was critically analyzed by 21 observing counselors across four metrics aimed at assessing the overall quality of the session (CRS), the quality of the therapeutic environment (PRS), the ability to form an alliance between therapist and client (SEQ), and the immersiveness of the VR (PQ). As a proof of concept study,

the goal of this research was to show that a quality therapy session could be achieved using this system. Thus, as long as the session was not hindered by using a prototype of this system across these four metrics, it would suggest that a version of this therapy system with more development could provide a valuable therapy option for people who feel they have no therapy option that works for them. Across all four metrics and all four indexes of the SEQ this therapy session performed as well or better than a neutral therapy session. In addition, it was found that the depth, overall quality, and perceived restorativeness of the therapy session was judged positively in comparison to a neutral therapy session.

Conclusion

Since the COVID-19 pandemic, the mental health burden has grown substantially in the United States with over 40% of the population struggling with some form of mental illness. In addition, less than half of those with mental health conditions receive any form of treatment. One approach to bridging this gap in treatment has been to increase the accessibility of treatment options by providing mental healthcare right where the patients are in the form of remote therapy. While these therapy solutions have been successful in providing an outlet for many people, these options have several limitations particularly for isolated populations. Two major limitations for current remote therapy options are the lack of control over the patients' environment and the difficultly in the fullness of communication over distance. In this study, a potential solution to these issues, a novel VR therapy system, is being proposed and assessed as a proof of concept.

CHAPTER 5: Determine the functionality and usability of the novel common factors based VR therapy system for patients

Abstract

Millions of people in the United States and around the world are affected by mental illness in some form including, more than 40% of the population since the COVID-19 pandemic. In addition, more than 40% of them receive no treatment for their mental illness whatsoever [1]. Some reasons for this discrepancy include several barriers to treatment such as stigma, prohibitive cost, and a feeling that treatment is inaccessible to them [8], [10]. Some populations that experience an even larger between need and treatment include rural, psychologically isolated, and poorer communities [12]. A novel remote VR psychotherapy system developed at the University of Kansas is assessed for its functionality and usability for patients. 30 adults experiencing depressive symptoms and seeking counseling were given a single Solutions Focused counseling session via either Zoom videoconferencing or the novel VR psychotherapy system. Participants rated the environment in the VR therapy as more restorative and a positive effect size was found for the depth of the counseling session. The VR therapy system performed comparably in client reactions, positivity, arousal, and presence. Future work will be to develop more avatars and environments, continue the development for a smoother therapy experience, and assess the system in a longitudinal study.

Keywords: Virtual Reality, EEG, Remote Psychotherapy, Common Factors Theory

Introduction

Mental illnesses affect millions of people in the United States and around the world every year. Previously, mental illnesses consistently affected over 20% of the population. However, since the COVID-19 pandemic, mental illnesses affect more than 40% of the population in the United States

[1]. Rural, psychologically isolated, and poorer communities receive mental health services at a lower rate than other populations [1], [12]. Some major reasons for this disparity include lack of resources in rural communities and increased physical distance for the nearest counseling office, stigma and anxiety towards attending counseling sessions in person, and the inability to afford counseling sessions [8], [10], [14], [20]. With the COVID-19 pandemic making in person psychotherapy sessions impossible, counselors have turned to telepsychology or remote mental health care to reach their clients. Since 2020, 98% of mental health care professionals have used some form of telepsychology in their practice [22]. Remote technologies are beneficial alternatives to in person therapy beyond addressing the restrictions of the COVID-19 pandemic, because they provide an accessible option for treatment for those who live far from the nearest counseling center that meets their needs (rural or geographically isolated), those who find the idea of getting out of bed in the morning and meeting their counselors in person impossible (psychologically isolated), and those concerned with the stigma of attending in person counseling sessions. Current technologies for telepsychology include online therapy companies (Betterhelp, Talkspace), videoconferencing services (Zoom, Zoom Pro, Doxy.me), and phone or text based therapy. For many, these technologies have provided a valuable lifeline during the pandemic and a valuable alternative to in person therapy independently of the pandemic [22]. However, for some, the shift to remote counseling has meant therapists and clients have had to adjust to this new form of treatment. With the distance of remote counseling particularly for sessions where the face is not visible as may be necessary for certain populations, it can become more difficult for counselors to recognize nonverbal cues, the client's environment may not be suitable for therapeutic healing, and the face to face nature of videoconferencing therapy can still cause too much anxiety for clients [21], [96].

For populations in which current counseling options do not meet their needs, new technologies could provide a solution. The environment of counseling session and counselor and client's ability to form an alliance or partnership together are critical components to therapeutic healing. Therefore, new technologies for remote psychotherapy should be designed to address the therapeutic environment and therapeutic alliance. A therapy system that utilizes virtual reality (VR) technology and electroencephalography (EEG) could provide the potential tools for counselors to address those needs. VR has the ability to immerse users into the virtual environment and build presence, or the feeling of truly being there in the space. It has been successfully used to treat anxiety and phobias through VR exposure therapy (VRET), foster self-compassion and mitigate self-criticism, and treat depression with positive psychology, cognitive behavioral therapy (CBT), and group therapy [52], [53], [57], [62], [63], [82], [83]. In addition, EEG has shown the ability to recognize client's emotions in real time [97], [103], [110]. Understanding client emotions is essential for counselors to build rapport with their clients, recognize moments when clients are anxious or responding to something the counselor said, and build a working relationship with their clients. It is proposed that utilizing a novel VR and EEG psychotherapy system that is designed based on the common factors of therapeutic healing can bring an effective and accessible therapy solution to isolated populations. In Chapter 4, the therapy system was assessed for counselors' ability to conduct counseling sessions using this system. This study assesses the system for its usability and functionality for clients. A human subject study to compare Zoom videoconferencing therapy to the novel VR psychotherapy system was conducted to assess the system based on its environment, its ability to foster the therapeutic alliance, its ability to instill presence in clients, and its ability to facilitate quality counseling sessions over distance.

Methods

The purpose of this study is to compare the functionality and usability of the novel VR psychotherapy system to that of Zoom video conferencing therapy for patients. Zoom and VR based counseling sessions were conducted for people struggling depression and anxiety in the local areas. Participants were offered one free 45-60 minute counseling session, asked to complete surveys before and after their session, and offered a referral to the Positive Psychology Clinic at the University of Kansas following their session. Counseling sessions were conducted at the Center for Psychoeducation Services at the University of Kansas. Participants and counselors were separately into different rooms to simulate remote counseling. Seven counseling psychology PhD students at the University of Kansas administered the counseling sessions during the study. A brief description of the overall study design is as follows: 1. The patients are introduced to the study and given a brief set of instructions for their respective counseling sessions, 2. Then they are asked to complete a survey on demographic information and current mood, 3. Immediately following completion of the survey, they are taken to their counseling room and introduced to their counselor remotely, 4. The counselor and client conduct a 45-60 minute counseling session with a counselor who is a PhD counseling student at the University of Kansas, and 4. Following the session participants will complete surveys that assess the quality of the counseling session and the current mood.

Participants and Criteria for Inclusion

The study consisted of 30 participants from the local community in Lawrence, Kansas and the surrounding areas. The criteria for inclusion were as follows: 1. Participants needed to be adults, 18 years or older, 2. Currently experiencing depressive symptoms, and 3. Actively seeking

counseling. Participants were also asked to travel in person to the CPS to complete their session. The gender breakdown of the participants was as follows: 15 participants who identify as male (Control: 8, Experimental: 7), 13 participants who identify as female (Control: 6, Experimental: 7), and 2 participants who identify as non-binary (Control: 0, Experimental: 2). The age breakdown of participants is shown in **Figure 27**. Socioeconomic information was also collected as part of this study: 2 participants self-identify as having a low level of socioeconomic privilege (Control: 0, Experimental: 2), 14 participants self-identify as having an average level of socioeconomic privilege (Control: 7, Experimental: 7), 13 participants self-identify as having a high level of socioeconomic privilege (Control: 8, Experimental: 5), and 1 participant preferred not to answer (Control: 0, Experimental: 1).

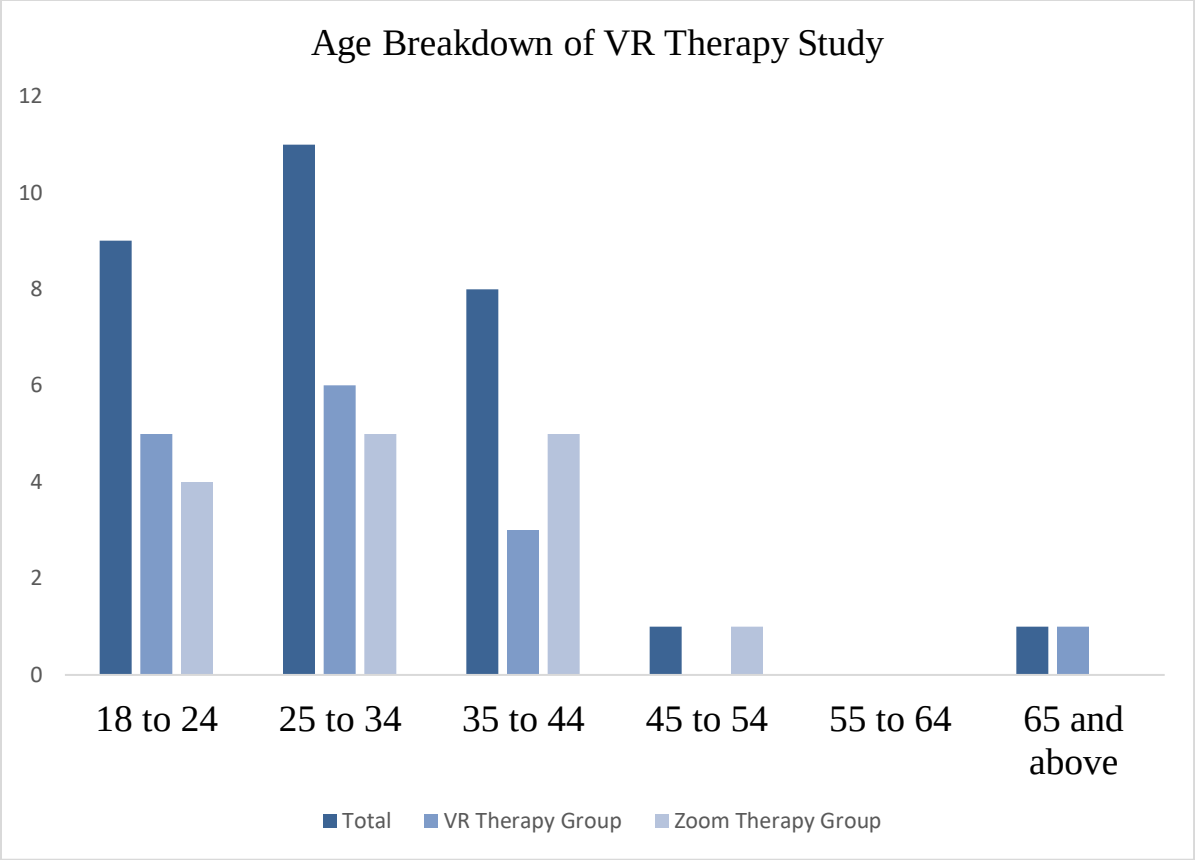

Figure 33. The age breakdown of the VR therapy study. 2 participants were 45 years or older and 9 participants were 24 years or younger.

Recruitment

Participants were recruited for the study in accordance with the guidelines by the University of Kansas international review board or IRB. The recruitment process for this study included advertising the study in the local student newspaper (offering a free VR counseling session and a referral), putting flyers up in academic buildings, and posting advertisements on social media including posts on Reddit in local subreddits and on the local newspaper's Instagram. The majority of participants identified that they heard of this study through posts on Reddit.

Figure 34. An example of the posted flyer on Instagram.

Groups

The experimental group was given a remote counseling session using the remote VR psychotherapy system. The counseling session occurred in a natural forest environment with a counselor represented by a therapist avatar. Depending on the preference of the counselor, the therapist avatar was either a male wizard or sage, or a woman healer. Participants did not meet with their counselor before the counseling session, only once in the virtual environment. The control group was given a remote counseling session using Zoom videoconferencing. Participants were taken to their counseling room and joined a video Zoom call with a counselor in a separate

room. Counseling sessions for both experimental and control groups following the same counseling script. Participants were randomly assigned to treatment or control groups. Treatment groups will receive pre and post tests before and after their VR session. Control groups will be given the pre and post tests before and after their online session and then be given an opportunity to try out the VR system.

Procedure

A brief description of an example study protocol:

1. The client is greeted by a secretary at the Center for Psychoeducation Services (CPS) at the University of Kansas and given a brief introduction to the activities for the session
2. The client was then asked to read and sign a consent form explaining the procedure as a participant and the potential risks involved.
3. The client was then asked to complete a brief survey on demographic information and current mood.
4. The client was then taken to their counseling room by a secretary and instructed on how to conduct their counseling sessions.
5. Once set up with their telepsychology system, they were connected with their counselor online.
6. The client then underwent 45-60 minute solutions focused counseling session, script discussed later.
7. Immediately following the counseling session, the client was briefed by their counselor, administered four surveys intended to evaluate the session and the current mood of the client.

8. Once finished with the post session service, the client was offered a referral to the University of Kansas positive psychology clinic and giving contact information of their counselor in case they need it to talk with them further.

Counseling script

The counseling script used for this study was developed by counseling psychology PhD student at the University of Kansas, Christopher McLamb and Christopher Tacca. The goal for the script was to create a guideline for counselors to conduct the sessions utilizing the technology at their disposal and give clients practical help and actionable changes after a single counseling session. The framework for counseling was a solution focused therapy model because it is intended to give clients immediate benefits in a singular session. Therefore, clients would be able to assess the quality of their counseling session after a singular session. One key aspect of solution focused therapy is the inclusion of the Miracle Question, which states that, "if you woke up in the morning and the problem that you were struggling with all of the sudden was completely resolved by some miracle, describe how that would feel for you" [130]–[132]. For counselors using the VR psychotherapy system, they were instructed to utilize the neurofeedback as they saw fit throughout the session. For example, if they noticed a moment where clients had a spike in their EEG, they could ask their client about what they noticed. Counselors could utilize the feedback either passively in their own head or bring up the EEG data directly with clients at various times throughout the session. Successful solutions focused counseling session leaves clients with a feeling that they have the agency to solve the issue that they are struggling with, with techniques to address their concerns, and with specific action plans to take for immediate change. The solution focused counseling script is included in the **Appendix**.

Study Metrics

The metrics chosen for this study were intended to assess the counseling session for the quality of the overall session, the restorativeness of the environment, the quality of the therapeutic alliance, and the ability of the technology to instill presence in participants. Surveys were taken by participants both before and immediately following their respective counseling sessions.

Pre-Session Demographic Survey

The demographic survey asked participants for their age, self-identified gender, and self-identified socioeconomic privilege. The demographic survey also asked the participant where they heard about the study.

Pre-Session and Post-Session Session Evaluation Questionnaire

The Session Evaluation Questionnaire (SEQ) is a common metric to assess the quality of a counseling session and client mood. The SEQ is broken down into four subscales: Depth, Smoothness, Positivity, and Arousal. The Depth and Smoothness subscales evaluate the counseling session, and the Positivity and Arousal subscales evaluate the client mood. The Depth and Smoothness subscales were administered to the client following the counseling session. The Positivity and Arousal subscales were administered to the client both before and after the counseling session to assess the change in mood across one session [40], [122], [129].

Perceived Restorativeness Scale

The Perceived Restorativeness Scale (PRS) is used to assess the environment of the counseling session. Clients rate how suitable an environment is for therapeutic healing including their comfort

level in the environment, excitement, and ability to focus on the counselor. Clients were asked to consider both the physical and virtual environment when completing the survey [116].

Client Reactions System

The Client Reactions System (CRS) is utilized to give a basic understanding of the client's feeling on the quality of the counseling session. They are asked to assess the quality of the session and give their immediate feedback of how they're feeling [121].

Presence Questionnaire

The Presence Questionnaire (PQ) is used to analyze the immersiveness of a VR experience. The VR technology is assessed based on presence or immersion, interactivity, and users opinion of the overall quality of the VR [123].

Statistics

The overall statistics for each of the study metrics are described below:

Session Evaluation Questionnaire: Mood

The SEQ mood subscales (Positivity and Arousal) were scored and analyzed with a 2 x 2 repeated measures Analysis of Variance (ANOVA) test.

Session Evaluation Questionnaire: Session Evaluation

The SEQ: Session Evaluation (Depth and Smoothness) subscales were scored and analyzed with a two sample t-tests to compare the score of the control and experimental groups.

PRS, CRS, and PQ

The PRS, CRS, and PQ were analyzed with a two sample t-tests to compare the means of the control and experimental groups.

Results

Overall, the goal of the VR therapy study was twofold: 1. To assess whether a quality counseling session is able to be conducted using the novel VR therapy system, and 2. To compare VR therapy with Zoom therapy and determine whether VR therapy could perform just as well or better in comparison to Zoom videoconferencing therapy.

Perceived Restorativeness Scale Results

The PRS was scored on a scale from 1 to 5 with a neutral score of 3. The mean score of the Zoom Therapy (Control Group) was 3.196 and the mean score for the VR Therapy (Experimental Group) was 3.549. Both groups rated the restorativeness of the environment as above the neutral score with a 95% confidence interval for the experimental group of 3.312 – 3.786. A significant

difference was found between the experimental and the control group with a p-value of 0.0036. The experimental group also had small positive effect size of 0.259 based on the Cohen's D test.

Client Reactions System Results

The CRS was scored on a scale from 1 to 5 with a neutral score of 3. The mean score of the Zoom Therapy (Control Group) was 3.873 and the mean score for the VR Therapy (Experimental Group) was 3.873. No significant difference between the control group and the experimental group was found. However, clients in both the control and experimental groups rated their immediately their immediate reactions towards the counseling session as positive in comparison to the neutral score with a 95% confidence interval for the experimental group of 3.679 – 4.067. No significant effect size was found.

Presence Questionnaire Results

The PQ was scored on a scale from 1 to 5 with a neutral score of 3. The mean score of the Zoom Therapy (Control Group) was 3.091 and the mean score of the VR Therapy (Experimental Group) was 3.056. No significant difference between the control group and the experimental group was found. Clients rated the immersiveness of the VR technology neutrally with a 95% confidence interval of 2.884 – 3.228. No significant effect size was found.

SEQ: Depth Results

The Depth score was scored on a scale from 1 to 7 with a neutral score of 4. Depth was calculated based on averaging the scores of the five questions in the SEQ related to depth. The mean Depth score of the Zoom therapy (Control Group) was 5.187 and the mean Depth score of the VR Therapy (Experimental Group) was 5.787. Both groups scored the depth of the session as positively

compared to the neutral score was a 95% confidence interval for the experimental group of 5.114 - 6.459. No significant different was found between the groups with a p-value of 0.0786. However, a large positive effect size of 0.6685 was found.

SEQ: Smoothness Results

The Smoothness score was scored on a scale from 1 to 7 with a neutral score of 4. Smoothness was calculated based on averaging the scores of the five questions in the SEQ related to smoothness. The mean Smoothness score of the Zoom therapy (Control Group) was 5.840 and the mean Depth score of the VR Therapy (Experimental Group) was 5.067. Both groups scored the smoothness of the session as positively compared to the neutral score was a 95% confidence interval for the experimental group of 4.263 – 5.870. No significant different was found between the groups with a p-value of 0.0586. However, a large negative effect size of -0.7235 was found.

Table 4. Summary of the Results to the VR Therapy Study. This study compared novel VR therapy to Zoom videoconferencing therapy across four metrics: Perceived Restorativeness Scale (PRS), Client Reactions System (CRS), Session Evaluation Questionnaire (SEQ), and Presence Questionnaire (PQ).

Study Metric	**Scale (Neutral Score)**	**Mean Score, Control**	**Mean Score, VR**	**SD, VR**	**P-value (t-test)**	**95% Confidence Interval, Low**	**95% Confidence Interval, High**	**Effect Size**
Perceived Restorativeness Scale (PRS)	1 to 5 (3)	3.196	3.549	1.288	**0.0036***	3.312	3.786	**0.259 ***
Client Reactions System (CRS)	1 to 5 (3)	3.873	3.873	1.253	1	3.679	4.067	0
Presence Questionnaire (PQ)	1 to 5 (3)	3.091	3.056	1.39	0.693	2.884	3.228	-0.026
SEQ: Depth	1 to 7 (4)	5.187	5.787	0.975	0.0781	5.114	6.459	**0.6685 ***
SEQ: Smoothness	1 to 7 (4)	5.840	5.067	1.234	0.0586	4.263	5.870	**-0.7235 ***
SEQ: Positivity Pre/Post	1 to 7 (4) *Post - Pre*	1.20	1.00					
SEQ: Arousal Pre/Post	1 to 7 (4) *Post - Pre*	-0.027	-0.413					

Alpha = 0.05

SEQ: Positivity Results

The Positivity was scored both pre- and post- session from 1 to 7 with a neutral score of 4. Positivity score was calculated by averaging the scores of the five questions related to positivity. The mean positivity score of the control group increased by 1.20 between pre- and post- session and the mean positivity score of the experimental group increased by 1.00 between pre- and post-session. No significant difference was found between the effects of the control and experimental groups. However, the overall main effects between pre- and post- session showed a significant positive difference across all groups.

Table 5. The SEQ Positivity results from the 2x2 repeated measures ANOVA.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Main Effects (Pre and Post)	Sphericity Assumed	18.150	1	18.150	29.824	**<.001***
	Greenhouse-Geisser	18.150	1.000	18.150	29.824	**<.001***
	Huynh-Feldt	18.150	1.000	18.150	29.824	**<.001***
	Lower-bound	18.150	1.000	18.150	29.824	**<.001***
Pre and Post * VR or Zoom Therapy	Sphericity Assumed	.150	1	.150	.246	.623
	Greenhouse-Geisser	.150	1.000	.150	.246	.623
	Huynh-Feldt	.150	1.000	.150	.246	.623
	Lower-bound	.150	1.000	.150	.246	.623
Error(Pre and Post)	Sphericity Assumed	17.040	28	.609		
	Greenhouse-Geisser	17.040	28.000	.609		
	Huynh-Feldt	17.040	28.000	.609		
	Lower-bound	17.040	28.000	.609		

Alpha = 0.05

SEQ: Arousal Results

The Arousal was scored both pre- and post- session from 1 to 7 with a neutral score of 4. Arousal score was calculated by averaging the scores of the five questions related to arousal. The mean arousal score of the control group decreased by 0.027 between pre- and post- session and the mean positivity score of the experimental group decreased by 0.413 between pre- and post- session. No significant difference was found between the effects of the control and experimental groups and no significant difference was found for the overall main effects between pre- and post- session.

Table 6. The SEQ Arousal results from the 2x2 repeated measures ANOVA.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Main Effects (Pre and Post)	Sphericity Assumed	.726	1	.726	1.189	.285
	Greenhouse-Geisser	.726	1.000	.726	1.189	.285
	Huynh-Feldt	.726	1.000	.726	1.189	.285
	Lower-bound	.726	1.000	.726	1.189	.285
Pre and Post * VR or Zoom Therapy	Sphericity Assumed	.561	1	.561	.918	.346
	Greenhouse-Geisser	.561	1.000	.561	.918	.346
	Huynh-Feldt	.561	1.000	.561	.918	.346
	Lower-bound	.561	1.000	.561	.918	.346
Error (Pre and Post)	Sphericity Assumed	17.093	28	.610		
	Greenhouse-Geisser	17.093	28.000	.610		
	Huynh-Feldt	17.093	28.000	.610		
	Lower-bound	17.093	28.000	.610		

Alpha = 0.05

Discussion

The VR therapy study consisted of 30 counseling sessions for adults struggling with depression who were seeking counseling. 15 participants underwent a single solutions focused remote counseling session using Zoom Videoconferencing and 15 participants underwent a single solutions focused remote counseling session using the novel VR psychotherapy system developed at the University of Kansas. Across all 30 sessions, clients rated their counseling sessions positively and a statistical difference in their positivity following the sessions was found. Qualitatively, many looked noticeably more positive and talkative following the sessions with many of them wanting to connect further with their counselors. We received a majority of positive feedback from both clients and counselors as part of the study. In particular, one client directly noted the influence of EEG, because their counselor seemed to continuously pick up things that they were feeling but did not know how to express. They said that it was a validating experience

for them, and that their counselor understood them. Many of the counselors were initially nervous to conduct counseling sessions with the VR therapy system. However, after completing their first session, they were excited and confident that they were able to have quality sessions. Clients also rated the restorativeness of the environment as statistically better in the VR therapy versus the Zoom therapy sessions. This was unexpected, because with the prototype the criterion for success was for the VR therapy system to perform relatively equal to the Zoom session, meaning that it could potentially be a viable form of treatment. However, clients rated their environment more positively in VR. With development, given the presence scores being relatively average, potentially a more immersive and developed virtual environment could score even better. In addition, a positive effect was found for the depth score between Zoom and VR counseling sessions. While not statistically significant, clients tended to have deeper sessions in the VR suggesting a stronger therapeutic alliance. A negative effect was found for the smoothness score between Zoom and VR. While not statistically significant, clients tended to view the Zoom counseling sessions as smoother. This was expected, because the VR system required more setup and experienced technical difficulties on occasion throughout. With further development to more streamline the setup process and with more experience with VR headsets, potentially clients could have even stronger experiences. In the context of the strong scores for session depth, client reactions, and perceived restorativeness with an initial prototype that could be improved for its smoothness, this shows even more potential for this system.

Some limitations to the remote counseling system were identified from situations encountered during the study. For example, one counselor was required to do a risk assessment on one of their clients while utilizing the VR therapy system. The counselor was able to complete the risk assessment remotely and had the situation necessitated some form of intervention, they were able

to go see them in person. However, in a truly remote psychotherapy system, this would not have been possible and other means of intervention must be investigated. In addition, one of the participants in the VR experienced some headaches and dizziness towards the end of their session while in the VR, so they had to remove the VR headset and complete the session via audio. This is a situation that is very possible, cybersickness is a known problem for some people using VR. Some improvements could be made to the presence in the VR to help mitigate the cybersickness and instituting a guide for using the VR in intervals and resting in between could help counselors navigate this problem.

Conclusion

Millions of people in the United States and around the world struggle with mental illnesses and receive no treatment for them. In addition, geographically remote, psychologically isolated, and poorer populations receive mental health care than other populations. Some of the reasons for the disparity in treatment include lack of assess to treatment nearby and a prohibitive cost. Remote psychotherapy systems have been developed to address the need for an alternative to in person therapy for populations where it is inaccessible, particularly during the COVID-19 pandemic. A novel VR remote psychotherapy system has been developed at the University of Kansas to address some of the limitations in the current remote psychotherapy options including fostering the therapeutic alliance over distance and bringing a restorative environment right to the client's home. This system was compared to Zoom videoconferencing across 30 different counseling sessions for local individuals in Lawrence, Kansas and the surrounding areas. The sessions were rated positively overall, rated statistically better in restorativeness of the environment, and rated stronger in the depth of sessions. All of this suggests that quality counseling sessions are able to be conducted through the VR psychotherapy system and that it could provide a necessary alternative

for those in which the current options are not suitable. Future research could investigate the impact of further immersion aspects into the VR such as in world interactivity and haptic feedback, improvements in EEG and real time alerts, and the implementation of further restorative environments and therapist avatars. In addition, a longitudinal study to investigate the long term efficacy of the VR psychotherapy system on the remote treatment of depression and anxiety.

CHAPTER 6: Discussion and Conclusion

The mental health burden in the United States is increasing and ever present. Since COVID-19 more people are struggling with mental illnesses than have in the recent past, over 40% of the population, and many of them receive no treatment whatsoever for their illnesses [1]. Psychotherapy has been shown to be an effective form of treatment for a wide variety of mental health conditions, however many decide to or are unable to seek psychotherapy treatment. Barriers to treatment include stigma, accessibility, and cost [8], [10]. This research focused on isolated populations, which in this context refers to populations in which in person counseling is inaccessible. Isolated populations can refer to rural communities in which the nearest therapy office is hours away, psychologically isolated populations in which the burden of leaving the home and meeting face to face with a counselor is too difficult, and poorer communities, in which in person counseling is cost prohibitive [12]–[17], [20]. For these populations, a remote alternative to in person counseling is necessary.

Since the COVID-19 pandemic, a vast majority of counseling practices were forced to begin conducting counseling sessions remotely. 98% of mental health professionals have now administered some form of remote counseling in comparison to 30% before the pandemic [22]. A lot have been learned since the outbreak of the pandemic and the shift to remote counseling. Remote counseling has the ability to be just as effective as in person counseling in terms of building a therapeutic alliance and patient outcomes, counselors while initially apprehensive are becoming more comfortable using remote technologies such as Zoom, Zoom Pro, and Doxy.me, and online mental health resources are becoming more present [96].

However, this research attempts to address the still ever present need for populations for which the current solutions still do not work for them. For example, videoconferencing solutions require clients to be in environments suitable for counseling, which is not possible for many of the people in the worst conditions with the most need. It also requires clients to be face-to-face with their therapist mitigating the benefits of reduced anxiety for clients who experience stigma and anxiety associated with treatment. To address these concerns a Virtual Reality (VR) and Electroencephalography (EEG) remote psychotherapy system based on the common factors of therapeutic healing was developed and assessed for functionality and usability. The common factors of therapeutic healing refer to the general factors necessary across all forms of therapy that contribute to the effectiveness of treatment [3], [4], [32], [36]. Two of the main common factors addressed in this research are the therapeutic environment and therapeutic alliance. The therapeutic environment refers to the setting in which the counseling takes place. For counseling to be effective, clients must be in a space where they feel comfortable, safe, and open to being vulnerable. Consider a client who is stressed and living in a space full of stimuli that increase their stress, conducting a counseling session in the exact same space as those stimuli would be difficult, such is the case in current remote therapy options. VR was chosen as a technology that could address these needs, because of its ability to make users feel as if they are there in the virtual environment. A therapeutic space designed in VR with the principles of restorative environments could give those who need remote counseling, but do not have access to a restorative space or do not wish to have a face to face counseling session an alternative that meets their therapeutic needs [74], [85], [86], [116]. The therapeutic alliance refers to the ability for the counselors and their clients to build a working relationship together. The alliance is formed through communicating deeply, building rapport, building trust, and having clear objectives. Fostering the therapeutic

alliance has been found to have a strong association with positive client outcomes. For remote counseling sessions, particularly in counseling session in the proposed VR, it can be difficult for the counselors to have all the information necessary to foster the therapeutic alliance with their clients. Over distance and without view of the client can make reading nonverbal cues and recognizing current emotions, both necessary for building rapport and trust, more difficult or impossible [39], [92]–[94], [115]. A live display of EEG neurofeedback data is proposed as a potential solution to this issue. Single channel consumer grade EEG headsets have been shown to accurately display human emotions, drowsiness, focus, engagement, and anxiety. They have also been used in a variety of mental health and human wellness applications. Three main objectives of this research were as follows: 1. Design and Develop a Common Factors based VR therapy system, 2. Assess the system for its usability and functionality for therapists, and 3. Assess the system for its usability and functionality for patients.

The approach for the development of a novel remote psychotherapy system was cross disciplinary in bioengineering, neuroscience, and counseling psychology. The purpose of this research was to use a bioengineering product design and development approach to address a problem that required an understanding of both counseling psychology and neuroscience. Thus, development would not only address engineering requirements such as remote connection, accurate EEG recordings, and immersive VR environments, but also address therapeutic healing requirements in counseling such as design considerations for restorative environments, counselor and client usability, and fostering the therapeutic alliance. Together, a unique psychotherapy system was developed based on combining information from a wide variety of fields. Ultimately, the focus of this research was on how the psychotherapy system could be useful for people, thus the most important aspect of the assessment was its use in real counseling sessions by real counselors and real clients in need.

The novel VR remote psychotherapy system developed included three restorative virtual environments (Forest World, Log Cabin, Freud Therapist Office), two therapist avatars (Wizard or Sage, Woman Healer), an EEG neurofeedback system (developed in MATLAB), a design for the therapist interface, and a design for the patient interface. Each element of the system was designed based on the common factors of therapeutic healing. The Forest World was inspired by the principles of restorative environments, nature therapy, and forest therapy [85], [86], [90]. The Log Cabin was intended as an indoor alternative to the Forest World and inspired by the principles of restorative environments. The Freud Therapist Office was inspired by the characteristics of Sigmund Freud's own therapist office in Vienna, Austria [127]. The therapist avatars were developed to personify the therapist characteristics associated better comfort for clients. These characteristics include being flexible, experienced, honest, respectful, trustworthy, confident, interested, alert, friendly, warm, and open [115]. Some common themes that are associated with these characteristics include expertness and wisdom, similarity and liking, compassion and empathy, and genuineness and trustworthiness. These characteristics were personified using the 12 common Jungian archetypes, which are widely recognizable and widely used in entertainment and media. The Wizard was chosen for its association with being expert and wise. The Woman Healer was chosen for its association with compassion and empathy [120]. The EEG neurofeedback system was developed to give real time information to therapists about the basic emotions of their clients. EEG data can be useful for counselors to recognize when their clients are feeling anxious, bored, or upset for any reason. Within the context of a counseling session, they can be interpreted by the counselor to give an idea of what the client is feeling and how to address it. Designs for the therapist and patient interface were proposed for real world use of this

system. The goals of these designs were to make the system easy to use, streamlined, and to give both counselors and patients more agency in their therapy.

The VR therapy system was assessed for its functionality and usability for therapists. 21 observing counselors assessed a mock counseling session using the VR therapy system for the restorativeness of its environment, basic quality of the session, depth, smoothness, positivity, arousal, and the quality of the presence in the VR. Across all metrics in the study, the VR therapy system rated favorably in comparison to the neutral scores of the metrics. In addition, the depth, overall quality, and perceived restorativeness of the therapy session was judged positively in comparison to a neutral therapy session.

The VR therapy system was assessed for its functionality and usability for clients. 30 local adults experiencing depressive symptoms and seeking counseling underwent a single 45-60 solutions focused counseling session via either Zoom Videoconferencing therapy or the novel VR psychotherapy system. The VR therapy system was compared to Zoom Videoconferencing therapy using four metrics: The Session Evaluation Questionnaire (SEQ), Perceived Restorativeness Scale (PRS), Client Reactions System (CRS), and Presence Questionnaire (PQ). The mood subscale (positivity and arousal) of the Session Evaluation Questionnaire was administered both before and after counseling sessions. The VR therapy system rated comparably to Zoom videoconferencing therapy in basic client reactions and presence, rated statistically better in perceived restorativeness, and showed a positive effect size for session depth (SEQ subcale). In addition, across all 30 counseling sessions a statistical positive difference in positivity between before and after counseling sessions was found.

An initial prototype of the VR therapy system was able to be used for real quality remote counseling sessions for individuals in the local community experiencing depressive symptoms.

The people that came in were struggling, on wait lists for counseling, intrigued by a different form of therapy, or brought in by loved ones concerned for their wellbeing. Each individual was looking for help and I believe many of them found it through this therapy. Many of them came in shy, apprehensive, and noticeably sad, but at least a few left optimistic, wanting to reconnect with their counselors, and excited by their experience. To me, this is evidence of the need of a counseling system like this, to give those people who feel like there is nothing out there that works for them, something different. The COVID-19 pandemic gave visibility to the need for better remote counseling systems, but the need was ever present long before the pandemic.

Further research into the use of this system in a longitudinal study, the development of therapist avatars for different therapist characteristics, gender, racial, and sexual identities, the development of future virtual restorative environments including nature environments with different climates, expansion of the open world concepts, and alternatives to the indoor Log Cabin, and development of the EEG neurofeedback system to be more visually appealing and useful for therapists.

Future Work: Longitudinal Study

The human subject study conducted in this research project focused on the single session functionality and usability of the psychotherapy system. Thus, it utilized a counseling modality intending for developing visible and usable results after a single session, solution focused therapy. However, most clients do not achieve lasting therapeutic healing after a single counseling session, and typically the journey towards healing can be a long, difficult process. A longitudinal study could be useful to determining how the psychotherapy system functions over time and whether clients and counselors still respond positively to using VR remote psychotherapy after several sessions. For example, it is unclear if the novelty of conducting a counseling session via VR had a significant impact on the clients experience with the system.

Future Work: Therapist Avatars

Therapist avatars will be developed based on other common Jungian archetypes that cross correlate with positive therapist characteristics. For example, an Everyman (useful for promoting similarity and liking), Hero (useful in displaying competence and courage), and Explorer (useful in promoting the sense of adventure present in nature therapy) therapist avatar could be developed and used as options for clients. In addition, it is important to develop therapist avatars with a variety of different gender, racial, and sexual identities so that clients can feel represented and counselors can feel more comfortable using an avatar that better represents themselves or how they would like to be viewed. One key future development would be a design your own avatar capability similar to a common feature in many video games that would allow counselors utilizing this system to either choose from a bank of already designed therapist avatars or create their own based on stock physical features and characteristics.

Future Work: Restorative Virtual Environments

Future work into the continued development of new virtual environments and the improvement of current virtual environments could help make a more immersive and customizable experience for clients. For example, the expansion of the open world virtual space can help give clients a larger feeling of agency during counseling sessions, giving them a feeling of being able to choose the space that they alone want. Environments based on different climates, with characteristics of other cultures, with more realistic or more fantastical elements, and with better movement and physics could all enhance the virtual experience. In regard to the movement in VR, it is especially important that the controls are intuitive, easy to use, and promote immersion. Thus, experimentation with other forms of movement in VR to determine the optimal modality could be beneficial to the overall client experience.

Future Work: EEG Neurofeedback

Future work to the EEG neurofeedback system could determine the best use of the live display to counselors. Currently, the system requires the counselors to process the meaning of the EEG data in real time, requiring counselors to expend an additional mental load on something other than directly treating their clients. For example, if a counselor notices a spike in Beta waves, it is up to them to determine what exactly that means for their client. Future work could develop a neurofeedback system that processes and characterizes the EEG signal for the counselors and displays simple advice or warnings to the counselor in easily digestible language. For example, the interface could display a visible symbol that indicates when the client is experiencing abnormal power in one or more of the frequency bands. With machine learning and the addition of context during counseling sessions, EEG data could be used to identify current emotional states more specifically. In addition, interactivity between the EEG and VR could enhance the immersiveness of the overall psychotherapy system. For example, if the colors, tone, or environmental assets in the virtual environments changed as a result of the emotional state of the client, it could help the client feel more comfortable in their own space. A simple application of this concept could be to introduce softer tones and calming music when a client is feeling anxious.

Overall Conclusion

The overall goal of this research was to conceptualize, develop, and assess a remote psychotherapy solution that addresses the needs of those left behind by current psychotherapy options. At this point, the psychotherapy system is in the early stages of development, but still has been shown to be a useful tool in conducting effective counseling sessions. Effective mental health care is built on understanding human beings, treating people with empathy, respect, and care, and reaching out to those who feel like they have no other options. Thus, this remote psychotherapy system could

prove to be another option for people who have not found a counseling solution that works for them. With future development in a multi-disciplinary fashion and a determination to continue making design decisions based on the needs of real people, a common factors based VR remote psychotherapy system could be an effective alternative for those in need. In a world with rising levels of anxiety, depression, isolation, and an ever present gap between those in need and those receiving treatment, the need for innovative new ideas and technologies is paramount.

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Appendix A: IRB Materials

Included in this appendix are the IRB materials for Specific Aim 3 including the human research protocol, consent form, recruitment materials, and counseling script.

Human Research Protocol

University of Kansas
Human Research Protocol
For use with eCompliance only

IRB: PROJECT INFORMATION

Project Title	Common Factors Based VR Psychotherapy Project
Investigator Name	Christopher Tacca
Faculty Supervisor (Students Only)	Barbara Kerr

This form must be used to submit an application through the eCompliance system.
No other methods of submission will be accepted.

Access the system at ecompliance.ku.edu

For faster processing, ensure all study staff have all completed the required Human Research Training.

Contact irb@ku.edu with any questions.

1. IRB: Subject Information

1.1 Number of Subjects:

30

1.2 Subject Age (*Check all that apply*)

☐ 0-7

☐ 8-17

☒ 18-65

☐ 65+

1.3 Special Populations (*Check all that apply)*

☐ Minors

☐ Non-English speaking

☐ Mentally or developmentally disabled individuals

☐ Pregnant Women

☐ Prisoners

☐ Individuals with diminished capacity for consent

☐ Individuals with a Legally Authorized Representative

☐ Other vulnerable population (describe below)

1.4 Describe any specific populations targeted for inclusion or exclusion.

Must be an adult, currently experiencing depressive symptoms and must be seeking counseling.

1.5 Describe target demographics of proposed subjects; explain how you will ensure that selection is equitable and that all relevant ethnic groups, genders, and populations have access to the study.

After the first 30 participants, a check will be done to insure that the sample so far is gender balanced and representative of the ethnic and racial diversity of the local population. If balance is not found, then extra efforts will be made to target recruitment to missing or minimal demographic groups.

2. IRB: RECRUITMENT

2.1 Describe the recruitment process for the study. Explain how you will gain access to and recruit the subjects for participation in this project.

The recruitment process for this study will include advertising the study in the local newspaper (offering a free VR counseling session and a referral), reaching out to students, emailing, putting flyers up in academic buildings, and posting advertisements on social media.

2.2 Identify any cooperating institutions by name.

No cooperating institutions.

2.3 External Study Team Members

☐ **External study team members (individuals NOT currently affiliated with KU) will collaborate on this project.**

If yes, explain external study team member's roles in the projects. Explain if they will be involved in a) obtaining consent of participants, b) interacting or intervening with participants, or c) have access to identifiable data.

Click here to enter text.

☐ **External study team member's home institution has an Institutional Review Board that is currently registered with OHRP**

2.4 Where will the research activities take place? List all off campus locations. Explain if this study will take place at more than one location/institution.

Activities will take place at the Center for Psychoeducational Services, 130 JRP

2.5 Identify all applicable recruitment methods.

☐ Flyers
☐ Letter
☐ Telephone
☒ Newspaper
☐ Poster
☒ Departmental Communication
☐ Purchased sample list
☐ Personal or Professional contacts

☐ Internet
☒ E-mail
☐ Online crowdsourcing sites (e.g., Amazon MTurk, Prolific, Qualtrics Panel)
☐ Social Media
☐ SONA
☐ Third party (Professional or Charitable Organization)
☐ Other

Please upload copies of materials in the "Recruitment Documents" section in eCompliance.*

2.6 Are you recruiting students from a class you teach or for which you have a responsibility?

No

2.7 Are you recruiting employees who directly or indirectly report to you?

No

2.8 If yes to 2.6 or 2.7, please explain why this population is necessary and describe what precautions have been taken to minimize potential undue influence or coercion.

Click here to enter text.

3. IRB: COMPENSATION

☒ **Subjects will <u>not</u> receive compensation**
☐ **Students will receive extra credit or course credit**
☐ **Subjects will receive monetary compensation**
☐ **Subjects will receive another form of compensation.** *Please explain in 3.1*

3.1 Describe the compensation or credit, including amount, scheduling, and method (e.g. ClinCard). Explain what will happen if subjects withdraw from the study.

No compensation.

☒ By checking this box, I understand that the HRPP is NOT granting approval for a specific method of payment and that I may need additional fiscal approval from the Office of Fiscal Affairs in order to pay research participants (Contact Kevin Teel @ 864-7775 for questions about participant payment).

Drawings and raffles may not be permitted for payment or recruitment; See HRPP website for detailed guidance.*

4. IRB: PROJECT INFORMATION

4.1 Expected study time period.

From: May 2022
To: August 2022

4.2 Do you currently have funding or expect to obtain funding in the future?
Yes

4.3 Select type of funding.
University (NFGRF, Graduate School, etc.), Madison and Lila Self Graduate Fellowship

If yes to 4.3, what is your award's current status?
Awarded

4.3a If this is an unfunded study and will provide compensation, describe the funds to be used (e.g., faculty start-up account, facilities and administration [F&A overhead] account, department account, or personal funds).
N/A

4.4 Describe the purpose of the research. Explain what is intended to be discovered; include goals, aims, and objectives and/or state the hypothesis to be tested.
This research aims to determine the functionality and usability of a novel common factors based virtual reality psychotherapy system for patients. Our goal is to conduct a proof of concept study that aims to compare the developed remote psychotherapy system that utilizes VR and neurofeedback to video conferencing based remote psychotherapy. Our hypothesis is that by creating a psychotherapy system that has immersive restorative virtual environments and basic live neurofeedback information for therapists, we can improve therapists ability to effectively treat clients remotely.

4.5 Research Topic Background: Provide a brief scientific or scholarly background for the research activities, address gaps in current knowledge. **Please include background information of your research topic. Do not submit personal background or resume/CV information.**
Mental health disorders such as depression and anxiety affect one in five adults in the United States. According to the 2019 National Survey on Drug Use and Health (NSDUH), non-serious mental illnesses are found in 29.4% of young adults aged 18-25 years old and 25% of adults aged 26-49 years old. In 2019, the NSDUH found that only 44.8% of all adults living with non-serious mental illnesses sought treatment. In 2020 and 2021 with the rise of the COVID-19 pandemic, 41.5% of US adults reported to have been struggling symptoms of an anxiety of depressive disorder. With this added burden, the increase in social isolation during the pandemic, and unknown long term psychological effects of the past year and a half, the need for an effective remote psychotherapy treatment is even more evident. The objective of this research is to address the growing need for a remote psychotherapy solution that is both

accessible for isolated patients and effective. One approach to therapeutic healing that is standard in counseling psychology is the use of psychotherapy based on common factors theory. This theory poses that there are several common factors that need to be addressed for healing to occur. This research focuses on two of the common factors that are most difficult to reproduce in remote psychotherapy: the therapeutic alliance and the therapeutic environment. We hypothesize that the use of a virtual reality (VR) and neurofeedback based psychotherapy system specifically designed based on common factors theory will lead to better performance in the therapeutic alliance between therapists and patients and ultimately, better outcomes for remote psychotherapy patients.

4.6 The revised Common Rule definition of a "Clinical Trial" is the following: *A research study in which one or more human subjects are prospectively assigned to one or more interventions (which may include placebo or other control) to evaluate the effects of the interventions on biomedical or behavioral health related outcomes.*

Does your study meet the definition for a "Clinical Trial?"

Yes

4.7 Does your project include community engaged collaborators (community-engaged research)? *Community-engaged research (CEnR) is defined as: a cooperative approach that includes partnerships and collaboration among researchers and community organizations/agencies. This includes, but is not limited to, involving community partners in the design and implementation of research objectives. Simply enrolling members of the community as research participants in study activities does not constitute community-engaged research.*

No

*****Community collaborators who are engaged with human subjects may need to complete CITI training and be listed on the study team.***

5. IRB: RISK & BENEFITS

5.1 Does this study involve any of the following? (*Check all that apply*)

☐ Deception
☐ Omission
☐ Misleading information/false feedback
☐ Physical or mental stress
☐ Collection of fluids or tissue
☐ Genetic information
☐ Substances taken internally or applied externally
☐ Mechanical or electrical device applied to subjects
☐ Information pertaining to illegal activity
☐ Information pertaining to substance use

☐ DXA Scan, X-RY, MRI
☐ Information relating to sexual attitudes, orientation or practice
☐ Private identifiable information
☒ Personal or sensitive information
☐ Private records (academic or medical)
☐ Social or economic burden to participants
☐ Exposure to hazardous materials
☐ Information that if released could damage an individual's financial standing, employability, reputation, or cause social stigmatization or discrimination
☐ Other
☐ None of these

5.2 Describe the nature and degree of the risk or harm checked above. If using deception or omission, include a justification for the deception or omission.

We will be conducting counseling sessions with our subjects and thus may be asking subjects questions that may involve them sharing personal information. However, these sessions will be conducted in a private setting and will not be recorded or have any bearing on the results of the study. In addition, we will be asking subjects to pick a topic of their choosing in order to ensure they will only be discussing information that they are comfortable with.

5.3 What steps will be taken to minimize the risks or harm and to protect the subject's welfare (when risk is greater than minimal)?

No identifying information will be collected on any subjects. Subjects will be able to choose the counseling topic that they prefer to ensure that they will only be discussing topics that they are comfortable with talking about.

5.4 Describe the anticipated benefits of the research for individual subjects.

Individual subjects will be given a free counseling session with a counselor supervised by a licensed psychologist. All subjects will be offered a referral for further counseling at the conclusion of the study.

5.5 Describe the anticipated benefits of the research for society or science, and explain how the benefits outweigh the risks.

The anticipated benefits of the research is the potential for a new form of treatment that can reach the countless people around the world struggling with mental illnesses and feeling like they have no way to get the help they need. In addition, this research aims to better understand the key elements that need to be addressed in remote psychotherapy and the ways in which we can design new systems to facilitate them.

6. IRB: DATA COLLECTION & SECURITY

6.1 Data Collection & Security

☐ Observation
☐ Interviews
☐ Focus groups
☒ Surveys/Questionnaires
☒ Psychological tests
☐ Educational tests
☐ Internet based methods
☐ Blood draw, saliva swabs, or other biological sampling
☐ Tissue biopsies
☐ Audio recording
☐ Video recording
☐ Previously collected data (no individual identifiers)
☐ Previously collected data (with individual identifiers)
☐ Other

*****Upload all data collection documents (surveys, specimen protocols, interview questions, etc) in the eCompliance "Supporting Documents" page.*****

6.2 Procedures (Describe the setting and tasks subjects will be asked to perform. Describe the frequency and duration of procedures, tests, and experiments. Include a time line or step by step listing.)

The study will be structured as a 2 by 2 experiment comparing pre- and post- results and control and experimental results. Each subject will undergo a 45 minute one on one mock counseling session with a licensed therapist. Beforehand, they will be asked to select a topic that they would like to discuss. An example of potential topic could be discussing a plan to improve study habits. Each therapy session will follow a standard solutions focused therapy structure. Solution focused counseling is appropriate for single sessions. The control group will undergo the therapy session over Zoom and the experimental group with undergo the therapy session using the VR /neurofeedback psychotherapy system developed at KU. The control group will be allowed to experience the VR environment for 15 minutes if they choose to at the end of their post-tests.

Process for Assigning Subjects to Control and Experiment Groups: Participants will be randomly assigned to treatment or control groups. Treatment groups will receive pre and post tests before and after their VR session. Control groups will be given the pre and post tests before and after their ONLINE session and then be given an opportunity to try out the VR system.

Procedure for Neurofeedback component of VR psychotherapy system: A commercially available Electroencephalography (EEG) headset (Open BCI Basic Headband) will be used during the counseling sessions in addition to the VR headset. The data from the EEG headset will be livestreamed in MATLAB over Bluetooth connection for the counselor to view during the therapy sessions. The basic headset uses three on top of the skin (forehead: left side, middle, right side) electrodes and only identifies basic brain activity levels in the form of frequency bands (Alpha (8 to 12 Hz) is associated with relaxation, Beta (12 – 30 Hz) with alertness, Gamma (30+ Hz) with creativity and flow, Delta (0.1 – 3 Hz) with dreamless sleep, and Theta (4 – 7 Hz) with dreaming). The EEG data streamed during the counseling session will NOT be recorded, and thus will be lost immediately following each counseling session.

Clarification of the use of EEG in the study: No variables will be recorded from the EEG, it will solely be live streamed through MATLAB to the counselor during the therapy session and will be used as a visual aide to the counselor as part of the novel VR/EEG therapy session invented at KU. The variables of EEG displayed to the counselor include as follows: 1. Raw signal, 2. Frequency gradient, 3. Magnitude of Alpha waves, 4. Magnitude of Beta waves, 5. Magnitude of Gamma waves, and 6. Magnitude of Delta waves. Counselors will have control over which of these variables they would like to view during the sessions. Alpha (8 to 12 Hz) is associated with relaxation, Beta (12 – 30 Hz) with alertness, Gamma (30+ Hz) with creativity and flow, Delta (0.1 – 3 Hz) with dreamless sleep, and Theta (4 – 7 Hz) with dreaming.

6.3 Sharing the results with Subjects or Others. (Indicate if results like tests or incidental findings will be shared with the subject or others and if so, indicate how it will be shared.)

Results of group data may be presented or published with no identifiers.

6.4 Withdrawal of Subjects (Describe the procedures to be followed when subjects withdraw from research or under what circumstances subjects may be withdrawn without their consent.)

Click here to enter text.

6.5 Protected Data to be Collected (*Check all that apply*)

☐ Protected Health Information
☐ Unique ID number (e.g. employee/student ID, driver's license number)
☐ Academic records
☐ Social Security Number
☐ Other personally identifiable information
☐ Data collected from participants located in the European Union

6.6 Describe the steps that will be taken to secure the data during storage, use, and transmission. How and where will the data be stored, for how long will it be kept, what safeguards are in place for data with identifying information. Include a description of physical and electronic security.

Data from the study will be collected in the form of pre- and post- surveys conducted on Qualtrics. No identifiable data will be collected as part of the study.

6.7 Identify any direct identifiers like name, unique identifier, address, e-mail, etc. that will be kept with the records. Explain why it is necessary to record the identifiers and describe the coding system to be used.

N/A

6.8 If retaining a link between study code numbers and direct identifiers after data collection is complete, please explain why this is necessary, how long the link will be kept, and how it will be stored.

N/A

6.9 Do you plan to make a de-identified version of the dataset public, provide the dataset to a publisher, or use the de-identified data for future research? If so, see consent templates for specific language to be included in the consent form.

No

6.10 If using audio and video recording, describe how the recordings will be used, how confidentiality will be maintained, and how and when the recordings will be destroyed or completely deidentified.

No audio or video recordings will be used in this study.

6.11 As part of the study will you:
a. Obtain protected health information (PHI) from a third party (such as a hospital or doctor's office)
b. Have access to PHI in the subject's records?
If yes to either a or b, please describe how you will satisfy the HIPAA requirements for authorization to use PHI in research below. (Submit the Statement on Use of Protected Health Information (PHI) form)

Click here to enter text.

7. IRB: INFORMED CONSENT

7.1 Specify the type of informed consent you will use with this research project.

*****Consent form templates can be found on the HRPP website. Please upload all consent form drafts to the "Consent Form" section in eCompliance.*****

☒ Signed Consent

Type of Consent
- ☒ Adult
- ☐ Parent/Guardian
- ☐ Assent Script/Procedures
- ☐ Foreign Language version

☐ Oral Consent (Waiver of documentation of consent, upload script in eCompliance)

☐ A signed consent form would be the only record linking the subjects to the research, and the principal risk of signing a consent form would be potential harm resulting from a breach of confidentiality
☐ The research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside the research context

☐ Information Statement
☐ Debriefing Statement
☐ Waiver of Consent is requested

A waiver of consent requires all five of the criteria below to be true. If a waiver of consent is requested, then provide a rationale for how your study meets each of the criteria.

1) The research involves no more than minimal risk to the subjects
   Click or tap here to enter text.

2) The waiver or alteration will not adversely affect the rights and welfare of the subjects
   Click or tap here to enter text.

3) The research could not practicably be carried out without the waiver or alteration
   Click or tap here to enter text.

4) Whenever appropriate, the subjects will be provided with additional pertinent information after participation
   Click or tap here to enter text.

5) If the research involves using identifiable private information or identifiable biospecimens, the research could NOT practicably be carried out without using such information or biospecimens in an identifiable format.
   Click or tap here to enter text.

See OHRP waiver of consent FAQs.

7.2 Describe any potential concerns with obtaining informed consent (Foreign language, minimizing possibility of coercion, etc.)

Click here to enter text.

7.3 Describe the process you will follow to obtain consent and/or assent. Include names of individuals on the research team who will obtain consent, where and when the process will take place and how you will ensure the subject's understanding.

Each participant who has sent an email address will be sent the consent form by the experimenters, Chris Tacca and Barbara Kerr, to return by three days before their appointment, along with an appointment time. Appointments will be made at the Center for Psychoeducational Services. The experimenter, Christopher Tacca, will be obtaining consent through online emails to the volunteers signed by the experimenter and Dr. Barbara Kerr. The experimenter, Christopher Tacca, will be collecting questionnaire data through Qualtrics.

Consent Form

Informed Consent Statement: Common Factors Based VR Psychotherapy Project

KEY INFORMATION

- This project is studying the functionality and usability of a novel VR psychotherapy system for the treatment of depression and anxiety.
- Your participation in this research project is completely voluntary.
- Your participation will take approximately 45 to 60 minutes.
- You will be asked to do the following procedures: 1. Select a topic of discussion for a mock therapy session 2. Complete pre- session surveys and questionnaires 3. Discuss topic of choosing with counselor for 45 minutes 3. Complete post- session surveys and questionnaires. More detailed information on the procedures can be found below.
- During this session, stressful emotions may arise related to the depression. If that is the case, further counseling will be offered through the Center for Psychoeducational Services. In addition, the participant may quit at any time without penalty and still be offered further counseling
- Research subjects will be given a 45 minute session with a licensed therapist to discuss an issue in their life that they would like to address. Following the therapy session, they will receive a referral for further counseling at the Center for Psychoeducational Services.
- Your alternative to participating in this research study is not to participate.
- All sessions are voluntary and participant may quit at any time, and still be offered referral for further counseling if they wish it.

DETAILED INFORMATION

INTRODUCTION

The Department of Educational Psychology and the Bioengineering Program at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, the services it may provide to you, or the University of Kansas.

PURPOSE OF THE STUDY

Determine the functionality and usability of the novel common factors based VR therapy system for patients.

PROCEDURES

You will be asked to first complete a set of four surveys aimed to assess your baseline mood, feelings toward therapy, goals for the sessions, and topic you wish to discuss. Once completed, the counselor will give you a brief introduction to explain the procedure for the sessions. The counselor will then take you through a 45 minute therapy session covering the topic of your choice. Therapy sessions will be conducted

using a novel Virtual Reality (VR) based therapy system developed at the University of Kansas. Thus, you will be asked to wear a mobile VR headset and an electroencephalography (EEG) headband during the counseling session. Instructions for wearing the headsets will be given to you by the instructor. The EEG headset will live stream your brain activity levels to the counselor during the session. However, it will not be recorded and will not be connected to you in any way following the therapy session. If you are uncomfortable with anything about the therapy sessions at any point, you are free to quit at any time without any penalty and you will still be offered further counseling if you would like. Afterwards, you will be asked to complete a set of four surveys to assess your thoughts on the effectiveness of the session.

Note: The experimental group will also be given a set of instructions for putting on the virtual reality headset and EEG neurofeedback system.

RISKS

During this session, stressful emotions may arise related to the depression. If that is the case, further counseling will be offered through the Center for Psychoeducational Services. In addition, the participant may quit at any time without penalty and still be offered further counseling .

BENEFITS

Research subjects will be given a 45 minute session with a licensed therapist to discuss an issue in their life that they would like to address. Following the therapy session, they will receive a referral for further counseling at the Center for Psychoeducational Services.

PAYMENT TO PARTICIPANTS

Research subjects will not be paid to participate in this study.

PARTICIPANT CONFIDENTIALITY

Your name will not be associated in any publication or presentation with the information collected about you or with the research findings from this study. Instead, the researcher(s) will use a study number or a pseudonym rather than your name. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form, you give permission for the use and disclosure of your information for purposes of this study at any time in the future.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas or to participate in any programs or events of the University of Kansas. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose further information collected about you, in writing, at any time, by sending your written request to: Dr. Barbara Kerr, 130 Q JRP Hall, University of Kansas, Lawrence, KS 66045.

If you cancel permission to use your information, the researchers will stop collecting additional information about you. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher(s) listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. I understand that if I have any additional questions about my rights as a research participant, I may call (785) 864-7429 or (785) 864-7385, write the Human Research Protection Program (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email irb@ku.edu.

I agree to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

_____ _____

Type/Print Participant's Name Date

_____

Participant's Signature

Researcher Contact Information

Christopher Tacca	Barbara Kerr, PhD
Principal Investigator	Faculty Supervisor
Bioengineering	Educational Psychology
2101 Learned Hall	130 Q JRP Hall
University of Kansas	University of Kansas
Lawrence, KS 66045	Lawrence, KS 66045
484 505 9019	785 864 9762

Recruitment Materials

Recruitment Materials – VR Therapy Project

To: University of Kansas Institutional Review Board

From: Christopher Tacca, Dr. Barbara Kerr

Date: March 15th, 2022

Subject: Recruitment Materials – VR Therapy Project

RECRUITMENT STATEMENT

VIRTUAL REALITY THERAPY FOR THE TREATMENT OF DEPRESSION AND ANXIETY

Principle Investigators: Christopher Tacca, Dr. Barbara Kerr

The purpose of this research study is to determine the functionality and usability of a novel virtual reality remote psychotherapy system for the treatment of depression and anxiety. To participate in this research, you must:

- Be 18 years or older
- Currently experiencing symptoms of depression or anxiety
- Seeking or currenting currently receiving psychotherapy

Participation in this study involves:

- A single counseling session with a therapist supervised by a licensed psychologist using a novel virtual reality therapy system or a Zoom videoconferencing based therapy system
- A time commitment between 90 – 120 minutes

At the conclusion of study participation. Participants will be offered a free referral to the Positive Psychology Clinic at the University of Kansas.

If you are interested in participating in this study, please contact:
Christopher Tacca, PhD Candidate, Principal Investigator, University of Kansas
+1 484-505-9019
Tacca.christopher@ku.edu

Counseling Script Developed by Christopher McLamb and Christopher Tacca

Counseling Session Script – VR Therapy Project

To: University of Kansas Institutional Review Board

From: Christopher Tacca, Dr. Barbara Kerr

Date: March 15th, 2022

Subject: Counseling Session Script – VR Therapy Project

SUMMARY

- 45 – 60 minute Solution Focused counseling session
- Two groups – Randomly Assigned
    - Control: Zoom Videoconferencing
    - Experimental: Common Factors Based VR Therapy
- Criteria for Conclusion: Adult, experiencing depressive symptoms, and seeking counseling
- Number of Subjects: Aim for 30

CONTROL GROUP SCRIPT

This counseling script serves as the basic guidelines for which the counselor will conduct the **Zoom conferencing based** psychotherapy session. It will begin with an **Introduction**, which will include basic introductory questions, instructions for the session, goal setting questions, and pre-session status questions. Once the client is comfortable and ready, the counselor will transition to the second part of the script, the **Solution Focused Intervention**. In this section, questions will act as guidelines for the counselor to use as they feel appropriate, with some suggestions for how to respond based on client answers. When the session is nearing completion, the counselor will transition to the **Conclusion** portion of the script. This section will include parting words and instructions for the post- session questionnaires.

Introduction
By the end of the section, initial introductions should be made, the counselor should have a brief idea of how the client is feeling initially and the client should be acclimated into Zoom Therapy Session.

In Person: Begin by introducing yourself, saying that it's great to be with them, and asking them if they know what to expect for the counseling session today.

Hi, I'm [Counselor Name], I will be helping you through your counseling session today. It's really nice to meet you. How have you been feeling?

Verbal Follow.

Okay well, I'm glad that you're here with me today. Today we will be conducting our counseling session through Zoom. Do you have any experience using Zoom before?

If yes…

Okay great! I will help you get set up on the Zoom call and I will give some brief instructions on how the therapy session will go.

If no…

Okay, no problem at all! I will help you get set up on the Zoom call, walk you through how it works, and give you some brief instructions on how the therapy session will go.

Once you are all set up, I will be moving to conduct the session in another room, but if you need anything we will be connected over Zoom, so you can just let me know and I'll be right there to help you out with anything.

Does all of this sound okay to you?

If yes…

Great, do you have any other questions for me before we start the session?

If yes…

Answer the question. Anything else?

If no…

Great, I will get you set up on the Zoom call now then.

If no…

What can I do to make this session more comfortable for you?

Address their concerns as best you can, and ask if they are comfortable being the counseling session now. If not, we may not be able to give them a counseling session, but we will still ask them if they'd like to have a referral for the Positive Psychology clinic. Refer to referral section of script.

If concerns adequately addressed…

Great, do you have any other question for me before we start the session?

If yes…

Answer the question. Anything else?

If no…

Great, I will get you set up on the Zoom call now then.

You help client get set up. Once the client is on Zoom and ready to go, and you are in the other room on the computer, begin next part of script.

On the Zoom call…

Hi, are you able to hear me okay?

Let's get started. Is it okay for us to speak with the video on or would you prefer us to have the video off?

If video off…

Turn video off.

If video on…

Proceed.

How does it feel being in this space today?

Verbal Follow.

Before we get started, do you have any questions or concerns about our therapy session today?

If yes…

Address questions and concerns.

If no…

Proceed.

Proceed to Solution Focused Intervention.

Solution Focused Intervention

This section is aimed to provide suggestions for questions to ask during the Solution Focused Invention. Begin with the first question here, but after that feel free to ask any of the questions provided, provide verbal follow when necessary, and adlib when necessary.

1. How can I be helpful to you today?
    a. If not sure, or not specific, ask them what they would like to talk about today.

These next questions use at your convenience. Please try to ask the majority of these questions by the end of the therapy session.

Pre-Session Change Questions:

2. How did you manage to get out of bed and make it here today?

Competency/Coping Questions:

3. Tell me about your good qualities.
4. How did you keep it from getting worse?
5. How are you managing to cope with this to the degree that you are?
6. How did you manage to get back on the right track?
    a. If they say they are not, tell them that just by taking the step to be here today to work on this is evidence that you are.
7. What positive things would your parent/teacher/other say about you?

Scaling Questions:

8. On a scale from 1 to 10, where 1 is the worst and 10 is the best, where are you today?
9. What will it look like when you're a 10.
10. How would others see that you have taken a small step toward improvement?

Goal Setting Questions:

11. What would you like to see happen by the end of our session today?
12. What would be different in your life when you have reached your goal?
13. How will you know that your goal has been reached?

Conclusion

When you feel like you have addressed their concerns enough for one day or we are out of time, begin this section.

Tell them that you will enter the room now. From this point on you will be talking with them in person.

Do you feel like you have an idea of some positive steps you can take to address the concerns you had today and reach the goals you set for yourself?

Verbal Follow.

How did you feel the mode/environment of treatment contributed to the therapy session? Do you have any thoughts on how it could be improved?

Verbal Follow.

At the conclusion of all our counseling sessions, we offer a referral to our Positive Psychology clinic, would you be interested in receiving a referral?

If yes…

Make a referral for them to the Positive Psychology clinic

If no…

Proceed.

Thank you so much for coming to talk with me today, that was a great step towards reaching your goals and I'm happy you were able to take that step with me today. If you have any questions about what we talked about today please feel free to contact me at [Email] or if you have any questions about the Research Study, please feel free to contact our principle investigators, Dr. Barbara Kerr at bkerr@ku.edu and Christopher Tacca at tacca.christopher@ku.edu.

Begin to walk with them out of the clinic.

This ends our time together today, but it was wonderful spending time with you and getting to know you today. I hope you found some positive steps to help you on your way to getting better. *Add any other closing remarks you'd like to say.*

EXPERIMENTAL GROUP SCRIPT

This counseling script serves as the basic guidelines for which the counselor will conduct the **Common Factors based VR** psychotherapy session. It will begin with an **Introduction**, which will include basic introductory questions, instructions for the technology and session, goal setting questions, and pre-session status questions. Once the client is comfortable and ready, the counselor will transition to the second part of the script, the **Solution Focused Intervention**. In this section, questions will act as guidelines for the counselor to use as they feel appropriate, with some suggestions for how to respond based on client answers. When the session is nearing completion, the counselor will transition to the **Conclusion** portion of the script. This section will include parting words and instructions for the post- session questionnaires.

Introduction
By the end of the section, initial introductions should be made, the counselor should have a brief idea of how the client is feeling initially and the client should be acclimated into the VR environment.

Outside of VR: Begin by introducing yourself, saying that it's great to be with them, and asking them if they know what to expect for the counseling session today.

Hi, I'm [Counselor Name], I will be helping you through your counseling session today. It's really nice to meet you. How have you been feeling?

Verbal Follow.

Okay well, I'm glad that you're here with me today. Today we will be conducting our counseling session through Virtual Reality. Do you have any experience using VR before?

If yes…
Okay great! So, you'll be an expert then. I will help you put on the headset and once you're all set up, I will give you some instructions on how to move around in the environment.

If no…
Okay, no problem at all! I will help you put on the headset and get set up. Once you are in the Virtual Reality environment, I will walk you through how it works and how to move around.

Once you are all set up, I will be moving to conduct the session in another room, but if you need anything we will be connected over Zoom, so you can just let me know and I'll be right there to help you out with anything. As part of this session, we will also be using the EEG headset here. Are you familiar with EEG at all?

If yes…
Okay perfect! We will just be using a simple EEG headset that will just give me a basic idea how you might be feeling during the session in order for me to best help you today.

If no…

That's okay, I will just give you a brief explanation of what it is. The EEG headset is just a small electrical sensor, here (point out on headset), which just gives me a brief idea of how you're feeling during the session. This will help me to best help you today.

Does all of this sound okay to you?

If yes…

Great, do you have any other questions for me before we start in the VR?

If yes…

Answer the question. Anything else?

If no…

Great, I will get you set up in the headset now then.

If no…

What can I do to make this session more comfortable for you?

Address their concerns as best you can, and ask if they are comfortable being the counseling session now. If not, we may not be able to give them a counseling session, but we will still ask them if they'd like to have a referral for the Positive Psychology clinic. Refer to referral section of script.

If concerns adequately addressed…

Great, do you have any other question for me before we start in the VR?

If yes…

Answer the question. Anything else?

If no…

Great, I will get you set up in the headset now then.

Counselor helps client get set up. Once the client is fully in the VR and ready to go, and you are in the other room on the computer, begin next part of script.

In the Scene Selector Scene…

Hi, are you able to hear me okay?

Let's get started. I will just teach you a bit how to move around in the environment and let you practice and explore your surroundings.

Instructions for VR Movement:

1. *There are no buttons or controllers for client. The client will move in the direction that they are facing.*

2. *They will begin stationery, to start moving they will need to look straight up at the sky and they will begin moving in the direction of where they're facing until they'd like to stop.*
3. *When they'd like to stop, they will have to look straight down at the ground. They can then look around freely while remaining stationery. To start up again, refer to step 2.*

Okay, now let's have you try it out. Feel free to explore anywhere you'd like.

As the client starts to move around the environment, help them with any questions or struggles they may have. Once they start getting the hang of it…

Wow! You're really getting the hang of this. How does it feel being in this space today?

Verbal Follow.

Do you see that portal up ahead? That will take us to the forest world where we will be conducting our session today. Whenever you're ready, please head towards the portal. Before we begin, I will give you some time to explore that environment as well.

Once they are in the forest world, allow them to explore anywhere they want. Point out that you are the avatar in the environment, and that in a couple minutes, when they're done exploring, please meet me back at the entrance to the pathway. Then follow you to the place where the therapy session will begin. The avatar will take them there. If they have trouble finding the avatar, the arrow points in the avatar's direction at all times.

While they are exploring…
Ask them one or more of the following questions.

How are you feeling exploring in this environment?
What has been your favorite part about this space?
How do you feel this space contributes to the therapy experience?

When they're ready…

Whenever you're ready, please meet my avatar back at the start of the pathway. I will then take you to where we will be conducting our session today.

Proceed to Solution Focused Intervention.

Solution Focused Intervention
This section is aimed to provide suggestions for questions to ask during the Solution Focused Invention. Begin with the first question here, but after that feel free to ask any of the questions provided, provide verbal follow when necessary, and adlib when necessary.

The client will follow the avatar to a spot next to the pond near the waterfall. Once there, begin.

14. How can I be helpful to you today?

a. If not sure, or not specific, ask them what they would like to talk about today.

These next questions use at your convenience. Please try to ask the majority of these questions by the end of the therapy session.

Pre-Session Change Questions:

15. How did you manage to get out of bed and make it here today?

Competency/Coping Questions:

16. Tell me about your good qualities.
17. How did you keep it from getting worse?
18. How are you managing to cope with this to the degree that you are?
19. How did you manage to get back on the right track?
    a. If they say they are not, tell them that just by taking the step to be here today to work on this is evidence that you are.
20. What positive things would your parent/teacher/other say about you?

Scaling Questions:

21. On a scale from 1 to 10, where 1 is the worst and 10 is the best, where are you today?
22. What will it look like when you're a 10.
23. How would others see that you have taken a small step toward improvement?

Goal Setting Questions:

24. What would you like to see happen by the end of our session today?
25. What would be different in your life when you have reached your goal?
26. How will you know that your goal has been reached?

Conclusion

When you feel like you have addressed their concerns enough for one day or we are out of time, begin this section.

Tell them that you will enter the room, and help them with removing the headset. From this point on you will be talking with them in person.

Do you feel like you have an idea of some positive steps you can take to address the concerns you had today and reach the goals you set for yourself?

Verbal Follow.

How did you feel the mode/environment of treatment contributed to the therapy session? Do you have any thoughts on how it could be improved?

Verbal Follow.

At the conclusion of all our counseling sessions, we offer a referral to our Positive Psychology clinic, would you be interested in receiving a referral?

If yes…

Make a referral for them to the Positive Psychology clinic

If no…

Proceed.

Thank you so much for coming to talk with me today, that was a great step towards reaching your goals and I'm happy you were able to take that step with me today. If you have any questions about what we talked about today please feel free to contact me at [Email] or if you have any questions about the Research Study, please feel free to contact our principal investigators, Dr. Barbara Kerr at bkerr@ku.edu and Christopher Tacca at tacca.christopher@ku.edu.

Begin to walk with them out of the clinic.

This ends our time together today, but it was wonderful spending time with you and getting to know you today. I hope you found some positive steps to help you on your way to getting better. *Add any other closing remarks you'd like to say.*

Appendix B: Code Snapshots

Included in this Appendix are snapshots of code developed in this research including code for the movement in VR in C# and Live Display of EEG Data in MATLAB.

Movement in VR

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class PlayerWalk : MonoBehaviour
{
    public Transform vrCamera;
    public float toggleAngle = 30.0f;
    public float startAngle = 330.0f;
    public int playerSpeed;
    public Rigidbody rb;


    // Start is called before the first frame update
    void Start()
    {

    }

    // Update is called once per frame
    void Update()
```

```
    {
        rb = GetComponent<Rigidbody>();

        //Is character moving?
        //Currently Stopped
        if (rb.IsSleeping())
        {
            if (vrCamera.eulerAngles.x <= startAngle && vrCamera.eulerAngles.x > 270.0f)
            {
                transform.position = transform.position + Camera.main.transform.forward * pl
ayerSpeed * Time.deltaTime;
            }
        }
        //Currently Moving
        else
        {
            if (vrCamera.eulerAngles.x <= toggleAngle || vrCamera.eulerAngles.x > 90.0f)
            {
                transform.position = transform.position + Camera.main.transform.forward * pl
ayerSpeed * Time.deltaTime;
            }
        }

    }
}
```

Live Display of EEG Data in MATLAB App Designer

```
classdef Muse_livestream < matlab.apps.AppBase


% Properties that correspond to app components
properties (Access = public)
UIFigure matlab.ui.Figure
ClicktoStartEEGCollectionButton matlab.ui.control.Button
UIAxes5 matlab.ui.control.UIAxes
UIAxes4 matlab.ui.control.UIAxes
UIAxes3 matlab.ui.control.UIAxes
UIAxes2 matlab.ui.control.UIAxes
UIAxes matlab.ui.control.UIAxes
end


% Callbacks that handle component events
methods (Access = private)


% Button pushed function: ClicktoStartEEGCollectionButton
function ClicktoStartEEGCollectionButtonPushed(app, event)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%
% This code was made using the work from the University of Victoria
% Theoretical and Applied Neuroscience Laboratory


% Citation: UVicMUSE
% author = {Bardia Barabadi, Olav Krigolson},
% title = {uvic-muse},
% month = March,
% year = 2020,
```

```
% We will first connect the MUSE headset to the laptop using the following
% Commands in TERMINAL:


% conda activate muse_env
% uvicmuse


% Read in MUSE UDP
mu = MuseUdp();


% Plot Setup
ax = app.UIAxes;
ax1 = app.UIAxes2;
ax2 = app.UIAxes3;
ax3 = app.UIAxes4;
ax4 = app.UIAxes5;


xLabel = 'Present Time'; % x-axis label
yLabel = 'EEG Front Lobe Raw Data'; % y-axis label
yMax = 100; %y Maximum Value
yMin = -100; %y Minimum Value


% Frequency Band Min Max
yMax1 = 50;
yMin1 = -50;


min = 0;
max = 5;


delay = 0;
```

```
% Define Function Variables
time = 0;
data = 0;
timestamp = 0;
success = 0;
short_fft = 0;
af7 = 0;
af8 = 0;
af7_chunk = 0;
af8_chunk = 0;
data_frontal = 0;
data_frontal_chunk = 0;
X_chunk = 0;
f = 0;
data_win = 0;


% Setup
fs = 256; % Sampling Rate of MUSE
dt = 1/fs;
n = 1;
f = 0; %(O:n-1)*(fs/n); %Hz


% Frequency Bands Setup
% Filter Signal into different frequency ranges


% Alpha
f_alpha_low = 8; %Hz
f_alpha_high = 12; %Hz
```

```
% Beta
f_beta_low = 12; %Hz
f_beta_high = 30; %Hz


% Gamma
f_gamma_low = 30; %Hz
f_gamma_high = 60; %Hz


% Theta
f_theta_low = 4; %Hz
f_theta_high = 7; %Hz


% Filter Setup
[b_alpha, a_alpha] = butter(2,[f_alpha_low/(fs/2) f_alpha_high/(fs/2)]);
[b_beta, a_beta] = butter(2,[f_beta_low/(fs/2) f_beta_high/(fs/2)]);
[b_gamma, a_gamma] = butter(2,[f_gamma_low/(fs/2) f_gamma_high/(fs/2)]);
[b_theta, a_theta] = butter(2,[f_theta_low/(fs/2) f_alpha_high/(fs/2)]);


% Filter Pre Allocation
z1 = [];
z2 = [];
z3 = [];
z4 = [];


a_band = zeros(1,1000000);
b_band = zeros(1,1000000);
g_band = zeros(1,1000000);
t_band = zeros(1,1000000);
```

```
count = 1;


% Set up Plotgraph
plotGraph = plot(ax,data_frontal);
plotGraph1 = bar(ax1,f, X_chunk/n);
plotGraph2 = plot(ax2,a_band);
plotGraph3 = plot(ax3,b_band);
plotGraph4 = plot(ax4,g_band);


xlabel(ax,xLabel,"FontSize", 15);
ylabel(ax,yLabel,"FontSize", 15);


xlabel(ax1, 'Frequency (in hertz)');
title(ax1, 'Frequency Spectrum of EEG');


axis(ax,[yMin yMax min max]);


tic
while ishandle(plotGraph)
% Read in single sample Data
[data, timestamp, success] = mu.get_eeg_sample();


% Extract Data from Second and Third Channel: AF7 & AF8
fp7(count) = data(2);
fp8(count) = data(3);
mean_sample(count) = mean(data);
data_frontal(count) = (fp7(count) + fp8(count))/2;


% IF statement for Sliding Window
```

```
win_dim= 99;


if count > 100
data_win = data_frontal(count - win_dim:count);


% Frequency Bands
[a_band, z1] = filter(b_alpha,a_alpha,data_frontal,z1);
[b_band, z2] = filter(b_beta,a_beta,data_frontal,z2);
[g_band, z3] = filter(b_gamma,a_gamma,data_frontal,z3);
[t_band, z4] = filter(b_theta,a_theta,data_frontal,z4);




else
data_win = 0;
end
EEG = [fp7; fp8; mean_sample; data_frontal];
% FFT of Chunk Signal


fft_chunk = fft(data_win);
X_chunk = abs(data_win);
% Frequency Range
n = length(X_chunk);
f = (0:n-1)*(fs/n); %Hz


% Power
power = X_chunk.^2/n;
```

```
% Time Count
count = count + 1;
time(count) = 7*toc;
set(plotGraph, 'YData', data_frontal);
axis(ax,[time(count)-200 time(count)+200 yMin yMax]);


set(plotGraph2,'YData',a_band);
axis(ax2,[time(count)-100 time(count)+100 yMin1 yMax1]);


set(plotGraph3,'YData',b_band);
axis(ax3,[time(count)-100 time(count)+100 yMin1 yMax1]);
set(plotGraph4,'YData', g_band);
axis(ax4,[time(count)-100 time(count)+100 yMin1 yMax1]);
if mod(count,20) == 0
set(plotGraph1, 'XData',f,'YData', power);
end
%set(plotGraph1, 'XData',[1 2 3],'YData', [1 5 2]);


axis(ax1,[0,100,0,50]);


            pause(delay);



        end


    end
end


% Component initialization
```

```
methods (Access = private)

    % Create UIFigure and components
    function createComponents(app)

        % Create UIFigure and hide until all components are created
        app.UIFigure = uifigure('Visible', 'off');
        app.UIFigure.Position = [100 100 1609 892];
        app.UIFigure.Name = 'MATLAB App';

        % Create UIAxes
        app.UIAxes = uiaxes(app.UIFigure);
        title(app.UIAxes, 'EEG Data')
        xlabel(app.UIAxes, 'Time')
        ylabel(app.UIAxes, 'EEG')
        zlabel(app.UIAxes, 'Z')
        app.UIAxes.Position = [38 212 755 661];

        % Create UIAxes2
        app.UIAxes2 = uiaxes(app.UIFigure);
        title(app.UIAxes2, 'Title')
        xlabel(app.UIAxes2, 'X')
        ylabel(app.UIAxes2, 'Y')
        zlabel(app.UIAxes2, 'Z')
        app.UIAxes2.Position = [825 746 757 147];

        % Create UIAxes3
        app.UIAxes3 = uiaxes(app.UIFigure);
        title(app.UIAxes3, 'Alpha Waves: Relaxation')
        xlabel(app.UIAxes3, 'Time')
```

```
            ylabel(app.UIAxes3, 'Y')
            zlabel(app.UIAxes3, 'Z')
            app.UIAxes3.Position = [825 548 757 185];

            % Create UIAxes4
            app.UIAxes4 = uiaxes(app.UIFigure);
            title(app.UIAxes4, 'Beta Waves: Alertness')
            xlabel(app.UIAxes4, 'Time')
            ylabel(app.UIAxes4, 'Y')
            zlabel(app.UIAxes4, 'Z')
            app.UIAxes4.Position = [825 345 757 185];

            % Create UIAxes5
            app.UIAxes5 = uiaxes(app.UIFigure);
            title(app.UIAxes5, 'Gamma Waves: Flow')
            xlabel(app.UIAxes5, 'Time')
            ylabel(app.UIAxes5, 'Y')
            zlabel(app.UIAxes5, 'Z')
            app.UIAxes5.Position = [825 138 757 185];

            % Create ClicktoStartEEGCollectionButton
            app.ClicktoStartEEGCollectionButton = uibutton(app.UIFigure, 'push');
            app.ClicktoStartEEGCollectionButton.ButtonPushedFcn = createCallbackFcn(app,
@ClicktoStartEEGCollectionButtonPushed, true);
            app.ClicktoStartEEGCollectionButton.Position = [602 37 408 77];
            app.ClicktoStartEEGCollectionButton.Text = 'Click to Start EEG Collection';

            % Show the figure after all components are created
            app.UIFigure.Visible = 'on';
        end
```

```
end

% App creation and deletion
methods (Access = public)

    % Construct app
    function app = Muse_livestream

        % Create UIFigure and components
        createComponents(app)

        % Register the app with App Designer
        registerApp(app, app.UIFigure)

        if nargout == 0
            clear app
        end
    end

    % Code that executes before app deletion
    function delete(app)

        % Delete UIFigure when app is deleted
        delete(app.UIFigure)
    end
end
```

Appendix C: Initial Invention Design

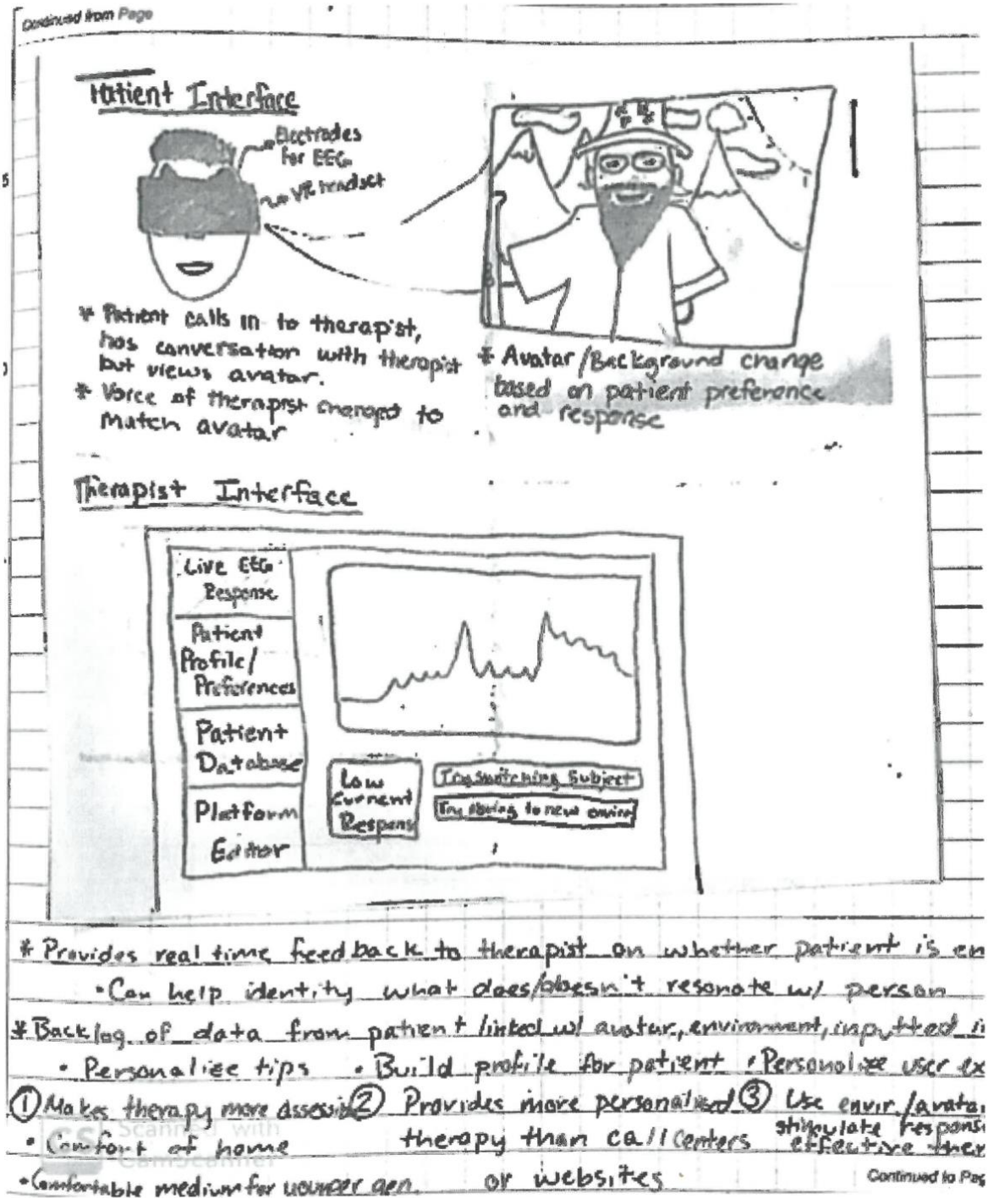
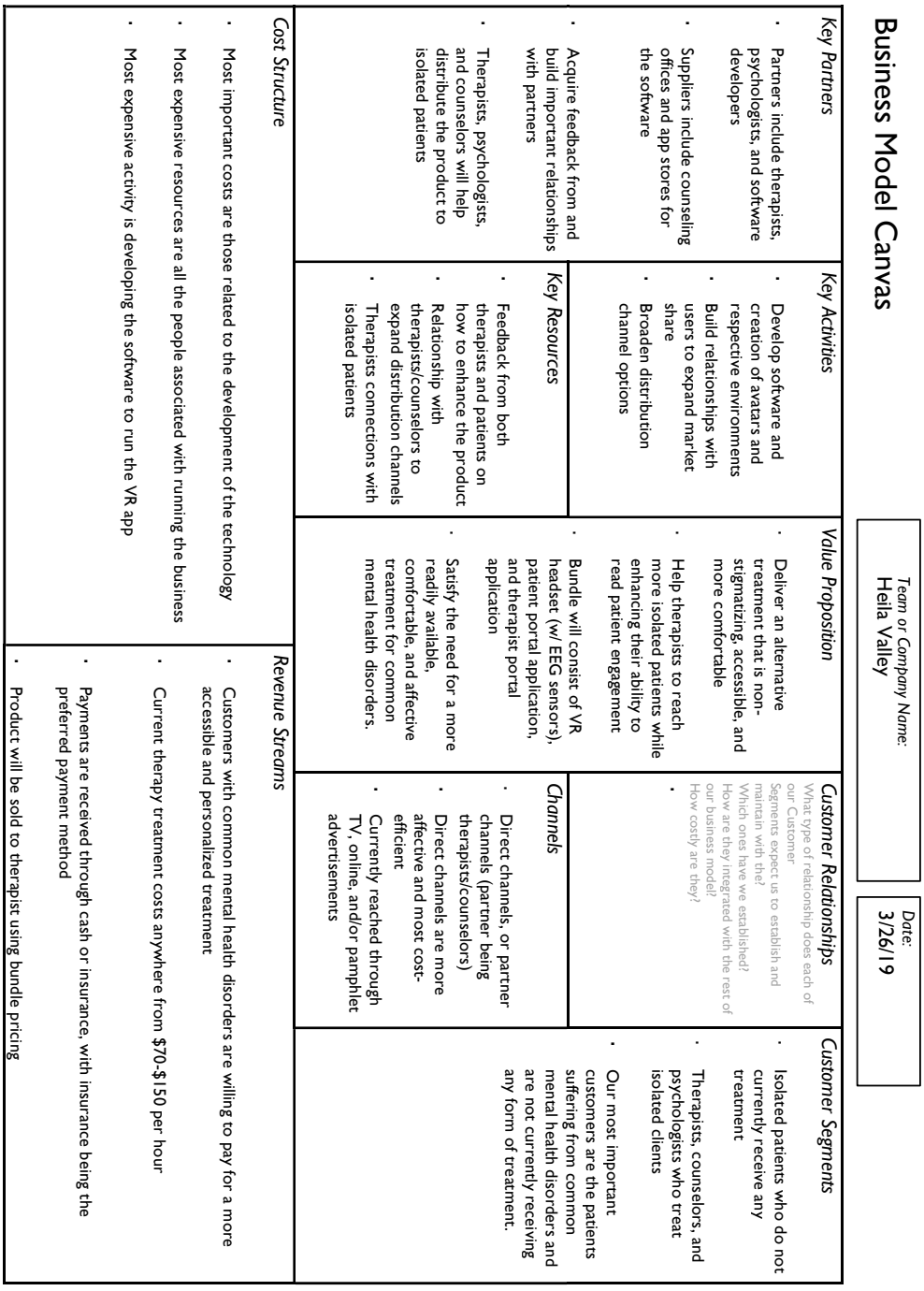


Figure 35. The initial design for the original concept of the VR psychotherapy system and initial rationale.

Appendix D: Business Model Canvas



Source: www.businessmodelgeneration.com

Figure 36. The initial business model canvas for the common factors based VR remote psychotherapy system.