Comparative Analysis of Emotional Responses in Virtual Reality and In-Person Interactions

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Abstract

This paper explores the emotional responses of individuals with moderate social anxiety in both in-person and virtual reality (VR) settings to determine VR's efficacy as a therapeutic tool. With the increasing prevalence of social anxiety, particularly post-COVID-19 due to heightened social isolation, innovative interventions are necessary. Utilizing a mixed-methods approach, we compared physiological responses (heart rate and electrodermal activity), self-reported emotions, and behavioral observations across traditional and digital interaction platforms. The study involved five participants interacting in structured social scenarios within both a physical room and a VR environment using the Meta Quest Horizon app. Preliminary findings indicate that VR can closely mimic in-person interactions, evoking similar physiological and emotional responses, which suggests potential for therapeutic applications. However, participants also reported challenges in fully engaging with VR, pointing to the need for improved sensory and perceptual authenticity to better replicate real-life social cues. Our research contributes to understanding VR's role in managing social anxiety and proposes directions for future research to enhance the realism and therapeutic potential of VR experiences.

Keywords - Human-Computer Interaction, Social Anxiety, Virtual Reality

1 Introduction

Social anxiety disorder (SAD) is a common mental health condition characterized by an intense fear of social situations and a persistent fear of being negatively judged or evaluated by others. The prevalence of social anxiety disorder can vary across different populations and age groups[1]. Studies show that social anxiety and depression is on the rise, especially among people in age groups 18-24 [2]. Social anxiety disorder received little research attention and was not officially classified as a psychiatric disorder until the publication of the DSM-III (American Psychiatric Association, 1980). Recent years have witnessed a significant increase in clinical research, and since that time, there have been substantial contributions to the diagnosis, assessment and treatment of social anxiety [3]. Activities such as meetings or interactions with strangers, attending social gatherings, formal presentations and those requiring assertive behavior are commonly feared by individuals with social anxiety [4]. With a lifetime prevalence of 28.8% anxiety disorders are among the most common mental disorders in America and Europe[5]. [6] states that mental disorders have progressively become an important challenge for society, and worldwide, as the situation is further exacerbated by the economic impact of COVID-19 and changes in the way people socialize.

In this paper, we study the emotional responses among individuals who self-report moderate symptoms of social anxiety. This population often represents an underdiagnosed group that may not seek help due to the perceived mildness of their symptoms, potentially worsening their condition over time. Understanding the intricacies of their experiences can inform targeted interventions that prevent the progression to more severe anxiety disorders. Research in this area can help refine the screening tools to capture subtle manifestations of social anxiety, ensuring earlier and more accurate identification of those at risk.

During the COVID-19 global pandemic, there was a significant increase in people living in social isolation due to national lockdowns and restrictions on physical interaction and movement [7]. This had a detrimental effect on the mental wellbeing of people across the world, with many people suffering from "COVID 19-loneliness" [8]. Digital technologies offered a potential solution to this by providing support and facilitating social connection remotely. A study by [9] found that many people used video games to cope with the stressors of the pandemic. While most research focused on the mental wellbeing effects of gaming on 2D platforms such as gaming consoles, a study by [10] found that virtual reality(VR) gamers reported a significant increase in an improved sense of mental wellbeing throughout the pandemic. We extrapolate this idea to understand the social dynamics by comparing the physiological responses through a mixed methods research approach. We aim to find if VR can be employed to mitigate the effects of social anxiety.

In recent years, Virtual Reality (VR) has emerged with the potential to revolutionize how we interact with digital environments and with each other. As VR technology advances and becomes more accessible, it is important to understand the emotional dynamics it fosters in comparison to traditional in-person interactions. The emotional impact of VR is distinct due to its immersive and engaging nature, which can create a sense of presence and reality that traditional digital interactions often lack. Studies like [11] have shown that VR can evoke strong emotional responses due to its ability to simulate real-life situations and environments in a controlled setting. However, while these simulated interactions can mirror real-life experiences in many ways, there are intrinsic differences that may influence the user's emotional responses.

Clinical research around social anxiety has increased but there are gaps in research comparing how those who self-report as having social anxiety react emotionally to in-person vs. VR interactions. Performing a comparative study of emotional responses in VR versus in-person settings is essential for identifying these differences and understanding their implications. Such research can help pinpoint the aspects of VR that are most effective in bringing out desired emotional responses and those that may fall short compared to real-world interactions. Furthermore, examining emotional responses in these settings can provide insights into the psychological and physiological effects of VR, contributing to broader discussions about the impact of technology on human behavior and interaction. The findings from this study are expected to have implications not only for the design and implementation of VR systems but also for our understanding of human emotional dynamics in increasingly digital societies.

As VR increasingly gains popularity, consumer appeal [24], and becomes more integrated into our lives, we attempt to leverage this advancement in technology to understand how emotional responses differ in an in-person interaction vs. VR social interaction in the Meta Quest Horizon app. It is important to study this dynamic because people with extreme social anxiety can leverage VR to practice and improve their social skills in a safe space. VR allows the users to engage in social interactions without the real-world consequences. Many studies have shown that a gradual exposure to anxiety-inducing situations allows them to build confidence and coping strategies over time [12]. From immersive VR meetings to traditional face-to-face gatherings, the modalities of interaction vary greatly, but the emotional responses they provoke have not been thoroughly compared. This research seeks to fill that gap by systematically analyzing emotional reactions in both virtual and physical social scenarios.

Through a mixed methods research approach, we evaluate emotional responses across various dimensions such as intensity, valence, and arousal. By combining physiological responses, self-reported comfort levels and emotions, and behavioral assessments, we seek to understand how emotional reactions in virtual settings compare to those in real-life interactions. By enabling participants to engage in an unstructured and real setting, we expect to uncover certain aspects of human behavior that might remain concealed in controlled experiments.

Research Question:
How do emotional responses differ between in-person and virtual reality (VR) interactions in individuals who self-report to have social anxiety?

2 Method

2.1 Participants

For this study, we recruited five participants through a recruitment survey sent out two weeks before the commencement of the study at the University of Maryland Baltimore County. The survey required participants to self-report some level of social anxiety. We confirmed that the participants did not know each other and did not interact prior to the sessions.

To ensure anonymity, each participant was assigned a pseudonym for use in this paper. Of these, four participants met and interacted in pairs in-person, while the fifth participant, Ben, engaged with each of the other four participants individually in a virtual reality (VR) setting. In VR, Ben used a virtual avatar to interact one-on-one with the others, as depicted in figure 2. This setup allowed for a comparison between in-person interactions with a stranger and individual VR sessions with a virtual stranger.

Participant profiles:

- Ben is a 38 year old small business owner. Ben's purpose in the study was to act as a stranger in VR for the participants so his physiological data and self-reported emotional state information was not included. Ben interacted with each of the other participants 1:1 in VR.

- Cindy is a 33 year old female teacher. Cindy was aware that she had to talk to a stranger for this study and was feeling somewhat uncomfortable for the upcoming session.
- Megan, a 35-year-old woman, is currently working toward her PhD in Mechanical Engineering and is also the mother of a 3-year-old boy. She is outgoing and enjoys engaging with others. Hindi is her native language, but she is fluent in English as well. According to survey responses, she feels comfortable in her emotional state before beginning the session.
- Mike is a 24 year old male, pursuing Master's in Information Science at University of Maryland, Baltimore County. Mike is Indian and prefers interacting with people in Hindi. He mostly refrains from initiating conversations with strangers. He had finished most of his tasks for the day and was feeling comfortable before the study started.
- Sam is a 45 year old software engineer who felt somewhat uncomfortable prior to starting the in-person discussion.

2.2 Study Design

We examined the physiological and emotional responses of individuals with social anxiety during social interactions in two different settings: face-to-face and virtual reality (VR). We designed a study where two strangers interact in-person, and then each individually interacts with a separate stranger in VR, all while we measured physiological signals, recorded audio, and took observational notes on non-verbal cues. Behavioral responses such as tapping, fidgeting, eye-contact, etc were observed. The primary objective was to assess how participants reacted between the two scenarios and whether VR could serve as a less anxiety-inducing environment compared to traditional in-person interactions.

In our study, we conducted two one hour sessions - each session with two participants who were strangers. Having participants be unknown to each other was important to ensure that all interactions during the study would involve first-time encounters.

Based on difficulties we encountered in the VR pilot session, instead of using VR social platforms like VRChat, which presented challenges such as confirming if the other person was available to talk, or managing participant movement, we opted for a setup in the home area of the Meta Quest 2. This approach ensured that participants who had little to no experience with VR controllers did not struggle with the technology. Additionally, this approach ensured that the physiological data collected via the Empatica E4 wristband was not altered due to technological complexities.

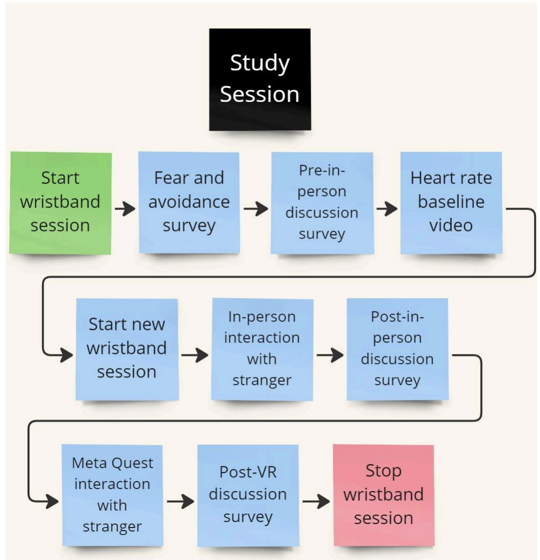

Fig 1. Study Procedure Flow.

For each session, we ensured that participants did not interact prior to the in-person session by placing them in separate rooms while they took the surveys and LSAS test. Each researcher supervised a participant individually. After obtaining written consent, we equipped participants with wristbands to start the data collection process. Participants were then brought together in the study lab where they first watched a 4-minute video to get baseline heart rate and EDA data.

Next, the participants sat down at a table facing each other. We recorded the audio of the participants' conversation to analyze later and we exited the room. For five minutes, participants interacted in an in-person discussion. Meanwhile, from the observation room, we observed and recorded notes on non-verbal cues such as leg shaking, fidgeting, and tapping. We interrupted the interaction at the end of the five minutes and asked the participants to complete the post-discussion survey.

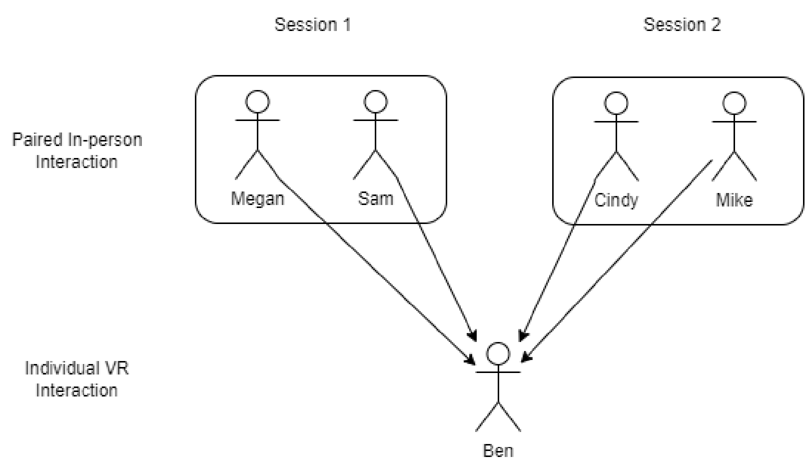

Fig 2. Participant interactions: 1:1 in person and 1:1 with the stranger in VR.

During a 15-minute break, we prepared a Meta Quest 2 for the participants to use to interact with the stranger in VR. We asked the stranger in VR to join the Meta home environment, as depicted in figure 3, and then we helped the participant put on the Meta Quest 2. Once the head-mounted display was on the participant, the stranger's avatar was immediately visible and the 5 minute discussion began. During the discussion, the participant can see the stranger's avatar, including the avatar's facial expressions. Similar to the in-person discussion, during the VR discussion, the researchers recorded timestamps, left the study lab and observed the interaction from the observation room, all while recording audio, recording physiological data using the Empatica wristband, and taking notes on non-verbal cues.

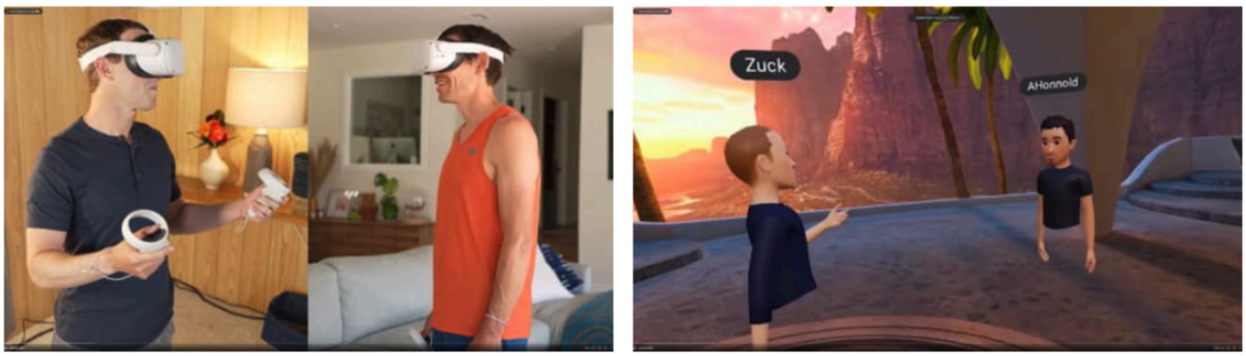

Fig 3. Facebook co-founder and CEO Mark Zuckerberg and legendary free-soloist Alex Honnold demonstrate the Meta Quest Horizon Home area [13].

Once each participant was finished with the VR discussion, we ended the Empatica session, and asked them to take a post-VR survey.

2.3 Data Collection Methods

We collected the data from multiple sources to analyze the emotional and physiological responses of participants. This included continuous physiological monitoring using the Empatica E4 wristband that recorded data such as heart rate and EDA (Electrodermal Activity). Additionally, all interactions were audio-recorded to capture verbal communications and subtle vocal inflections that might indicate emotional states. We also measured heart-rate which reflected the arousal levels during the interaction [14].

Surveys*:* We designed 3 short surveys for our participants - pre in-person discussion, Post in-person discussion and post-vr discussion surveys. These allowed us to understand the emotional state of our participants before and after the sessions and assess their comfort levels with one open ended question about how they felt during the interaction.

LSAS (Liebowitz Social Anxiety Scale) Test*:* We administered the Liebowitz Social Anxiety Scale (LSAS) questionnaire to the participants before the study began. LSAS is a valuable tool for self-reporting social anxiety levels in research. Originally developed as a clinician-administered scale by Dr. Michael R. Liebowitz, the LSAS has been adapted into a self-report version (LSAS-SR), which retains the effectiveness of the original while allowing for broader, more flexible usage in various research settings. This quantitative metric allowed us to identify the self-reported social anxiety scores of our participants. One of the key advantages of the LSAS over other self-reporting questionnaires is its strong psychometric properties, which include high reliability and validity, as well as detailed subscale measures that demonstrate high test-retest reliability [3]. The LSAS's structure allows it to capture a wide range of social interactions and performance anxieties, giving it a broader application than some other scales which might be more limited in scope.

***Audio Recordings**:* We recorded the audio for both in-person and VR interaction sessions which provided us with qualitative data. The tonality, loudness, and intonations of a person's voice can reveal a great deal about their emotional valence in social interactions where anxiety may alter these vocal characteristics. For instance, research has shown that individuals with social anxiety tend to speak with a lower volume and exhibit speech patterns that are less fluent, possibly due to nervousness or a lack of confidence [15]. These vocal cues can serve as indicators of the presence and severity of social anxiety. Tonality and intonation, specifically, play critical roles in conveying emotions. A higher pitch and variability in tone may express nervousness or stress, whereas a flat tone might suggest withdrawal or disinterest, which can be common in anxious individuals avoiding social engagement [16]. Loudness, too, is crucial; overly soft speech might indicate timidity or fear, while abrupt changes in loudness can suggest emotional instability or anxiety. Utilizing audio recordings allowed us to capture these aspects of speech and analyze them to assess emotional states during social interactions.

***Physiological Data**:* We recorded Electrodermal activity (EDA) and heart rate (HR) using the Empatica E4 wristband. EDA measures the skin's electrical conductance, which increases with sweat gland activity - a response controlled by the sympathetic nervous system often triggered by emotional arousal or stress [17]. This makes EDA a valuable indicator of anxiety as it directly reflects the autonomic response to social stressors. Heart rate, measured through interbeat intervals, and its variability (HRV) provide insights into autonomic nervous system functioning, where reduced HRV is associated with higher stress and anxiety levels [18]. These measurements are particularly effective during social interactions with strangers, as they can reveal changes in anxiety levels that may not be verbally expressed. For example, an increase in heart rate and EDA levels could indicate heightened anxiety when an individual engages in conversation with a stranger, providing a quantitative method to assess the intensity of social anxiety and the physiological impact of social stressors. Together, HR and EDA offer a comprehensive view of how the body physiologically reacts to social challenges, making them essential tools for studying the underlying mechanisms of social anxiety and evaluating the effectiveness of therapeutic interventions designed to manage this condition [19].

***Observational Notes**:* The researchers noted the non-verbal behaviors of the participants from the observation room during the in-person interactions. Behavioral cues such as shaking, fidgeting, and tapping can serve as significant markers of social anxiety due to their manifestation as physical symptoms of the internal state of anxiety. These behaviors often occur as involuntary responses to heightened stress or nervousness typically associated with social interactions in individuals with social anxiety disorder (SAD). Shaking or trembling, for instance, is a common response to adrenaline release, which is the body's natural reaction to perceived threats or anxiety-inducing situations [20]. Fidgeting or the inability to remain still can similarly be interpreted as a physical manifestation of mental restlessness and discomfort that accompanies social fears. Tapping, another frequent nervous habit, may serve as a self-soothing behavior that provides a temporary distraction from the anxiety felt during social engagements [21].

3 Findings

3.1 Data Analysis

During our study, we collected various data types including physiological measurements, audio recordings of each session, responses from the Liebowitz Anxiety Scale, as well as surveys that participants filled out before the in-person and VR discussions, and again after both sessions. Additionally, we observed during both discussion settings and took note of body language.

Physiological Data

With the Empatica wristbands, we gathered heart rate and EDA. We exported the data from the Empatica E4 connect website. We then organized the data for each participant for each scenario so that it was easily accessible. We added a timestamp column for each file in preparation for analyzing data alongside the audio recordings.

First we calculated the average HR and EDA for each participant in each scenario. Before normalizing the data, we compared the average baseline, in-person, and VR heart rates and EDA. Next, we normalized the data in order to more accurately assess and compare data across participants and sessions, ensuring that any variations due to individual differences in baseline levels or external factors were minimized. Once normalized, we took the average heart rate and EDA of each participant for the in-person discussion and compared to the VR discussion. We also did a t-test in order to determine if the differences between the two scenarios were statistically significant.

We created line graphs of the heart rate and EDA data for each participant to illustrate the following comparisons: heart rate and EDA in-person versus in VR, and each participant's heart rate and EDA versus their partner's in the in-person scenario.

Recorded Audio

For each audio recording, we used the associated timestamps in order to trim each file to match the physiological data. We analyzed the audio for tonality, topic of discussion, dominance of conversation, and more.

Thematic Time-Series Analysis

For each graph, we synchronized the corresponding audio recordings with the HR and EDA data. This allowed us to simultaneously listen to the audio and visually examine the peaks and valleys in the heart rate and electrodermal activity, providing a comprehensive analysis of the data. We utilized FigJam, a collaborative tool that enables multiple users to interact with images on a canvas, for our time-series analysis. While observing the graph in real-time and listening to the audio, we used FigJam's comment feature to annotate observations directly related to the data and corresponding audio. We defined thematic windows based on specific topics and themes discussed. Within these windows, we analyzed moments where HR and EDA levels showed significant fluctuations and drew conclusions with input from audio analysis, observational notes, and survey responses. We also noted instances of physiological synchrony, observing how participants' physiological responses aligned over time.

Non-Verbal Observations
We analyzed the notes we took from the observation room during both the in-person and VR scenarios and while doing the time-series analysis, we compared non-verbal notes and informed our conclusions.

Self-Reporting Survey Responses
Through the surveys, we gathered important data about each individual's typical anxiety baseline, how they were feeling in the moment, and how each individual perceived the in-person scenario compared to the VR experiences.

3.2 Results

Through our mixed methods approach to data analysis, we combined quantitative physiological measurements with qualitative audio insights, survey results, and non-verbal observations to capture a holistic view of participant responses. This integration allowed us to not only analyze the quantitative alone, but also helped us to understand the context.

Physiological Results
Through quantitative analysis, we compared average baseline, in-person, VR heart rate and EDA data. As shown in figure 4, At first glance, we noticed that the results were split 50/50 on which scenario produced a higher physiological response.

Averages Pre-Normalization

Name	Baseline HR	In-Person HR	VR HR	Baseline EDA	In-Person EDA	VR EDA
Cindy	72.3	106.6	84.6	0.17	2.3	1.1
Mike	62.7	78.6	87.7	0.47	1.97	1.5
Megan	64.1	70.2	78.8	0.15	0.24*	0.87*
Sam	74.2	87.7	85.7	0.59	1.04*	0.51*

All metrics are averages across the session and pre-normalization.
**EDA Data not reliable - may have been impacted by loose fitting.*

Fig 4. Average baseline, In-person HR and EDA, and VR HR and EDA for each participant (pre-normalization)

After normalizing the heart rate data, we did another comparison between in-person and VR (see figure 5). We found that with the normalized data, the average heart rates were higher during in-person sessions compared to virtual reality sessions. This suggests a greater physiological response in real-life social interactions among participants with self-reported social anxiety compared to those in VR.

T-Test

Participant	**Average in-Person HR (Normalized)**	**Average VR HR (Normalized)**
Cindy	0.7608361037	0.5907279413
Mike	0.4929508273	0.4753281174
Megan	0.6339326923	0.5627712968
Sam	0.6550237154	0.4496573213
T-Test Results	0.07541328638	

Fig 5. Average baseline, In-person HR compared to average VR HR (normalized) and T-Test results.

Next, we performed a t-test in order to statistically evaluate whether there is a significant difference in the average heart rates of participants between the in-person and VR discussion settings. As shown in figure 5, the t-test revealed that the p-value was 0.075, which exceeds the alpha threshold of 0.05. The alpha threshold of 0.05 is commonly used in statistical testing as a cut-off for determining significance; values below this threshold suggest that the observed results are likely not due to random chance. Therefore, since our p-value exceeds this threshold, we conclude that there is not a statistically significant difference between the average heart rates in in-person and VR settings.

Survey Results

After analyzing the Liebowitz Scale scores, as well as the self-reporting survey results, we made a few observations about the qualitative data. Both participants who self-reported to have social anxiety during the recruitment survey scored as little or no social anxiety on the Liebowitz scale and self-reported to be “somewhat comfortable” prior to the in-person discussion, indicating that the participants may have a false sense of being more anxious than they actually are. Also, those who had higher Liebowitz scores (Marked and Moderate) self-reported to be “Somewhat uncomfortable” prior to in-person discussion. This information further underscores the validity of the Liebowitz Social Anxiety Scale as an effective tool for predicting discomfort in real-world interactions.

After the in-person discussion, each participant noted that they were feeling either somewhat or very pleasant. Each participant noted that the interactions were enjoyable and reported that during the discussion they felt either somewhat comfortable or very comfortable.

Similarly, the results for the post-VR discussion showed that positive emotional valence persisted with each participant reporting feeling comfortable during the VR instance.

Non-Verbal Observation Results

We observed behaviors such as fidgeting, tapping, and hand gestures in both scenarios; however, these occurred more frequently during the in-person interactions compared to the VR settings, where they were noticeably less pronounced.

Thematic Time-Series Analysis Results

By analyzing the physiological data over time, while simultaneously reviewing the audio recordings and our non-verbal observation notes, we contextualized the physiological responses. During this analysis, we used topical windows to better grasp the subjects of conversation, the participants' tonality, and the emotional tone of the discussions (See figures 6-9). Some key trends and observations:

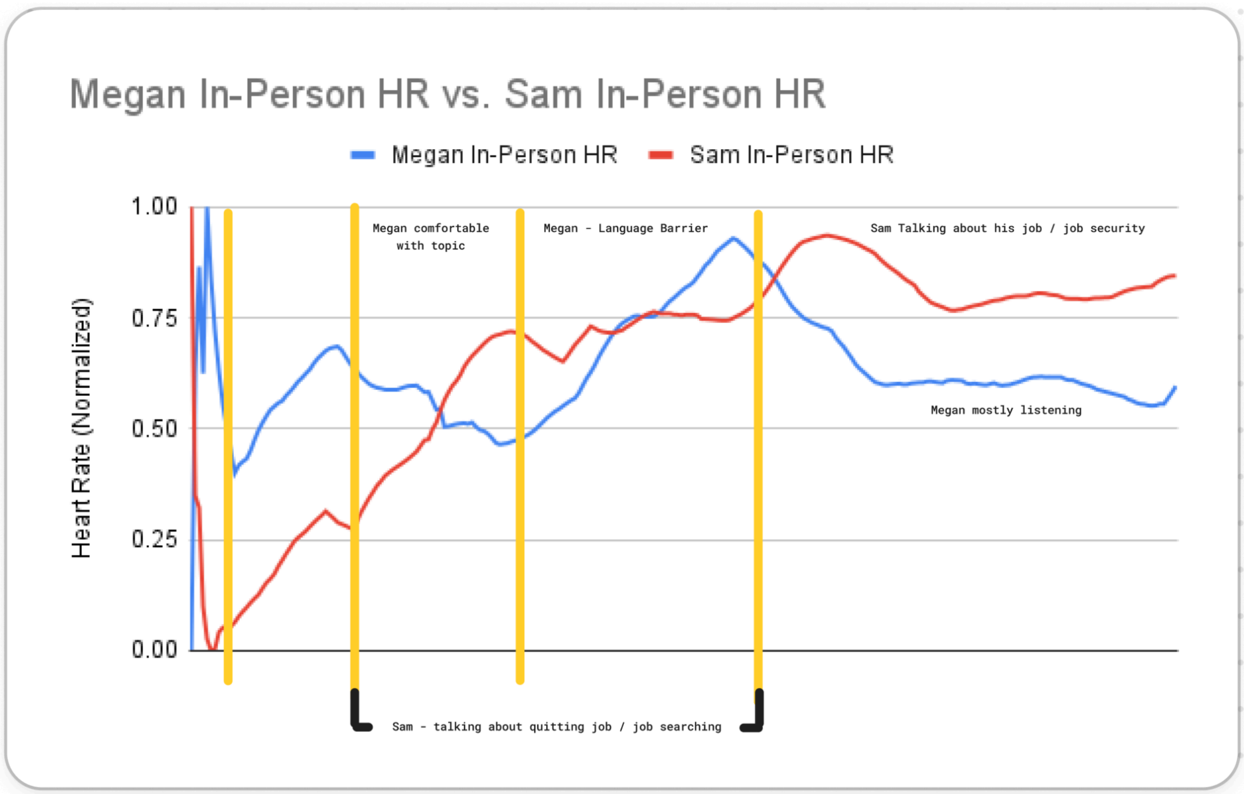

Fig 6. Thematic Time-Series Analysis of Megan and Sam's In-Person HR.

During our analysis, we observed instances where spikes in heart rate and electrodermal activity (EDA) did indicate stress. This was particularly evident when participants faced a language barrier, as shown in figure 6. When non-native English speakers posed questions that were not immediately understood, there were notable increases in their heart rate. Additionally, the audio recordings revealed moments of stammering and quieter speech from the participants before these physiological spikes occurred. Our findings suggest that stressors such as communicating in a non-native language can trigger moments of increased physiological stress.

Another instance where we observed a significant spike in heart rate was when a participant discussed quitting their job and the unexpectedly long subsequent job search (see figure 6). In addition to the heart rate spike, there was a discernible shift to a more serious tone in the participant's voice. The drastic increase in physiological data paired with audio analysis during this discussion indicated that the period of their job search was particularly stressful and triggering for them.

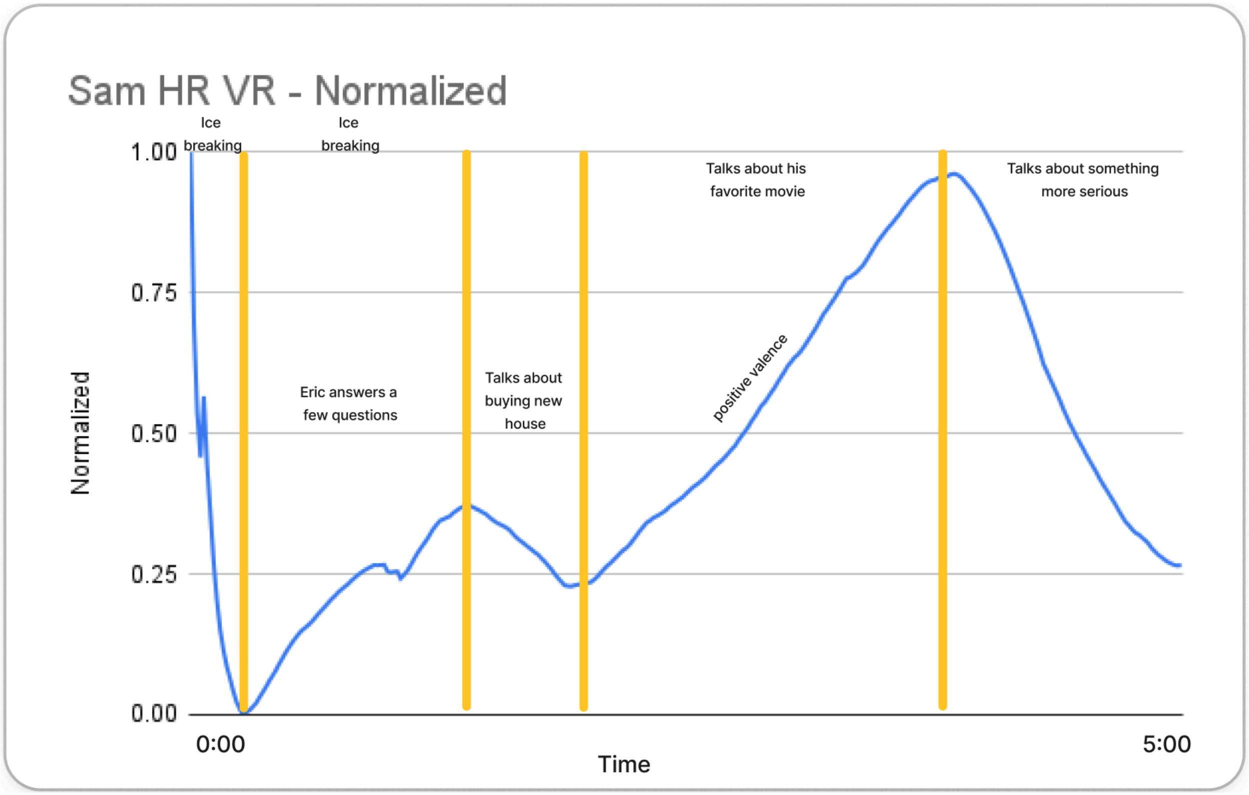

Fig 7. Thematic Time-Series Analysis of Sam's VR HR.

We also observed instances where spikes in heart rate (HR) indicated positive valence, as shown in figures 7-9. By synchronizing the audio with the physiological data graphs, we identified several moments when participants discussed their hobbies or passions - such as music, dancing, or anime - and noted corresponding increases in HR and electrodermal activity (EDA). Audio analysis revealed changes in tonality, reflecting excitement and joy while talking about these interests. This underscores the importance of multimodal analysis in interpreting physiological data, as it provides a more nuanced understanding of the emotional context behind the physiological responses.

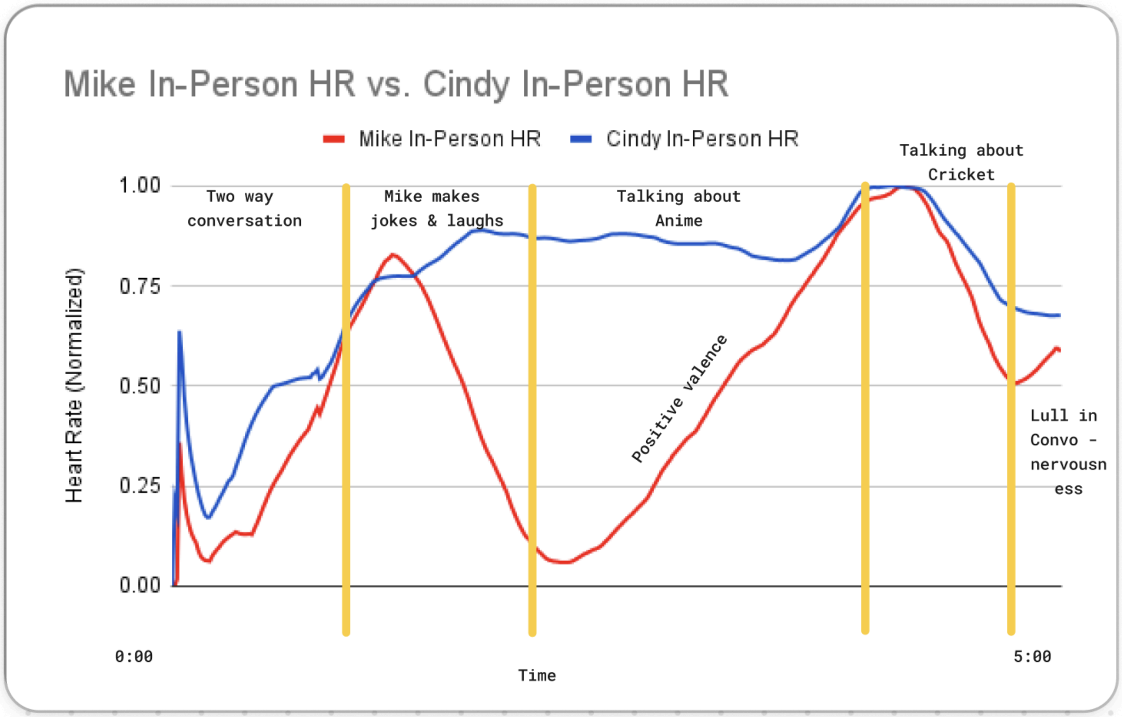

Fig 8. Thematic Time-Series Analysis of Mike and Cindy's In-Person HR.

There were also moments when decreases in heart rate and EDA suggested a reduction in stress. For instance, during the VR sessions, we observed that the participant's heart rate dipped while the stranger was speaking (see figures 9-10). Our hypothesis is that the participant felt more relaxed during these times, as the focus was not on them to speak. However, when it was the participant's turn to speak again, we noted a subsequent increase in heart rate.

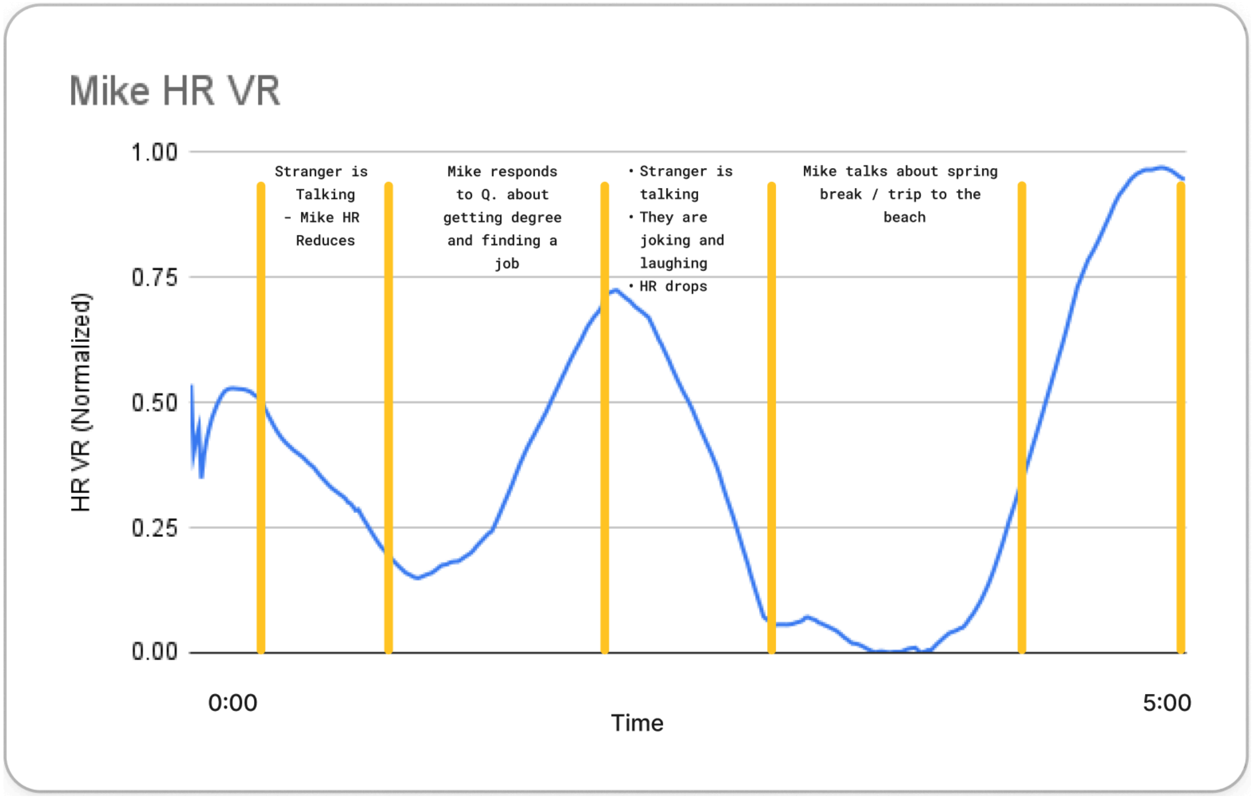

Fig 9. Thematic Time-Series Analysis of Mike's HR in VR

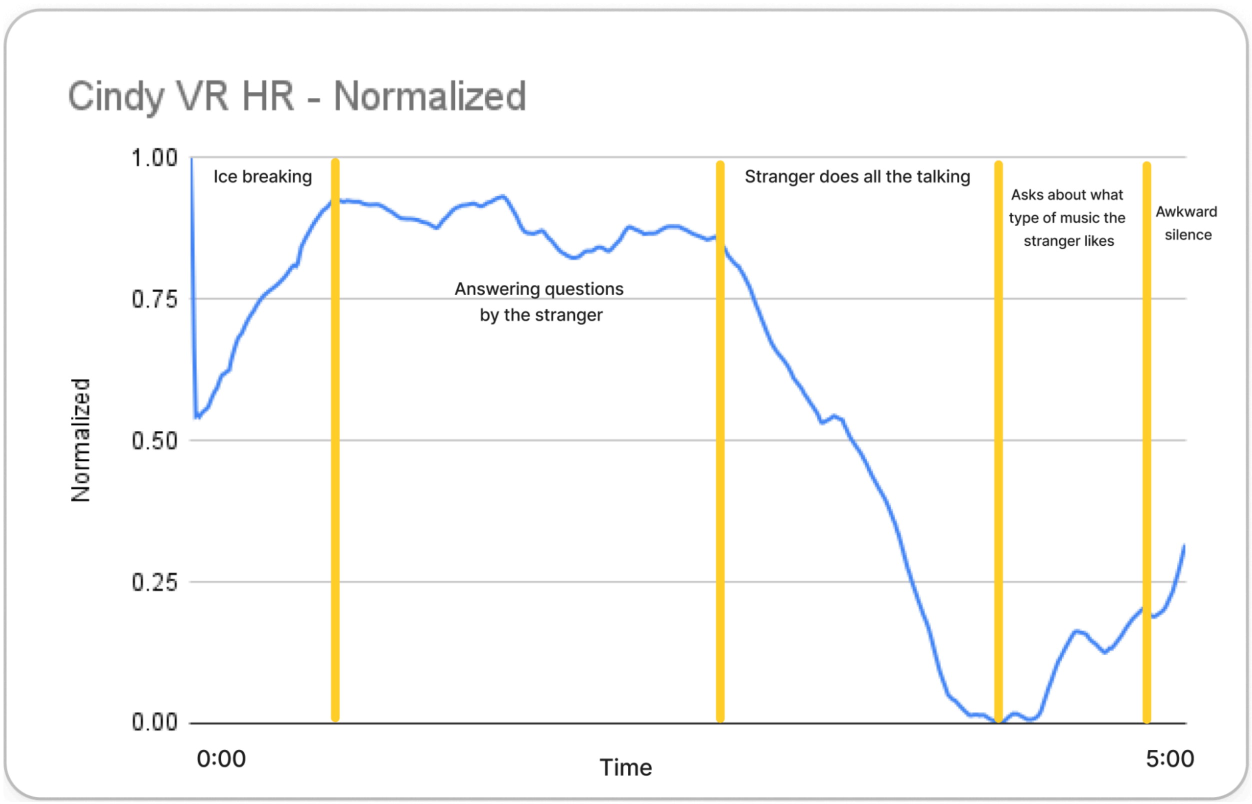

Fig 10. Thematic Time-Series Analysis of Cindy's HR in VR

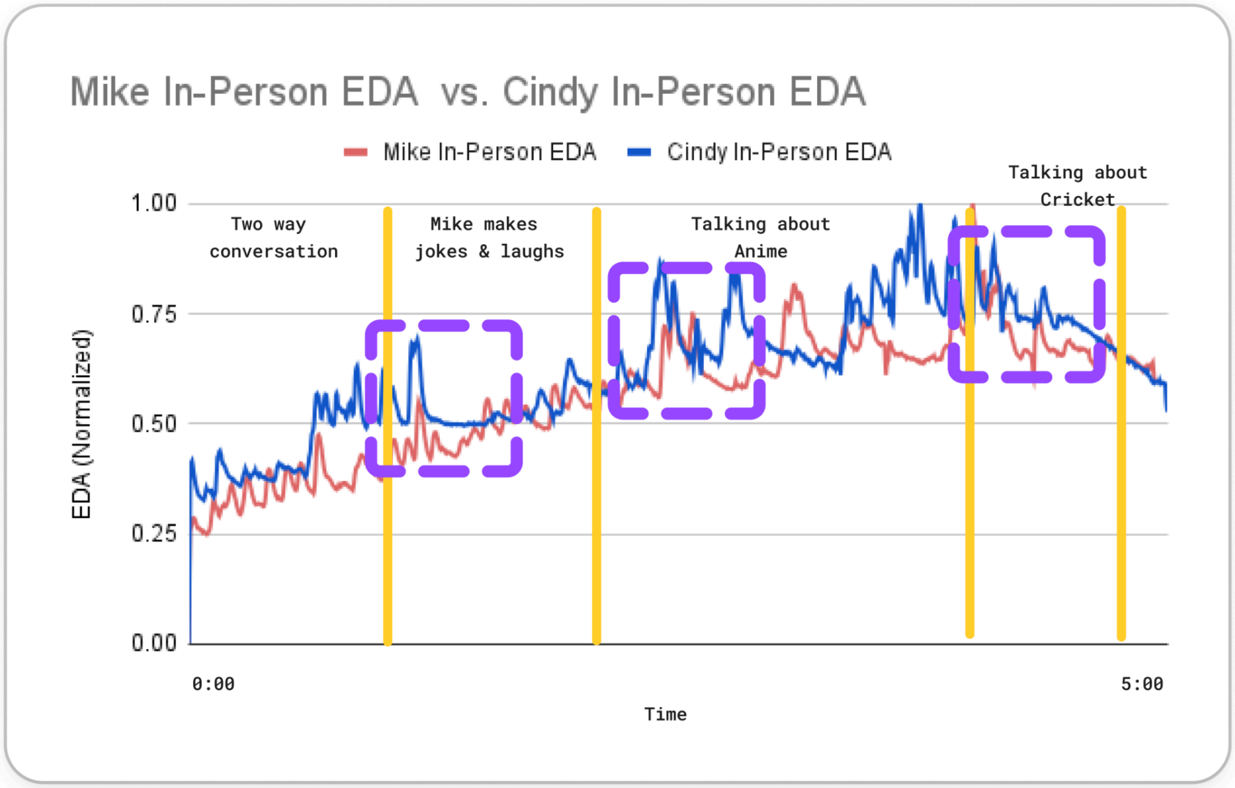

Fig 11. Moments of EDA synchrony during Mike and Cindy's in-person discussion.

Additionally, during the in-person scenario, we noticed several moments of HR and EDA synchrony or instances where changes in arousal happen synchronously between the two people [25]. Typically, the synchrony occurred during moments where the participants were joking and laughing or talking about hobbies or things they like, such as anime, music, dancing, or a book they're reading (See figures 8 and 11).

4 Discussion

Our findings contribute significantly to the emerging body of research on virtual reality (VR) as a tool for managing and possibly treating social anxiety. Throughout the study, participants engaged in both in-person and VR interactions, displaying positive emotional states in each scenario, as indicated by survey responses, audio analysis, and observations. Participants reported feeling comfortable and positive across both scenarios, underscoring VR's effectiveness in mimicking real-life interactions and highlighting its usefulness for simulating social exchanges.

The similarities in emotional responses between the in-person and VR scenarios are particularly interesting. Despite physiological metrics, such as heart rate (HR) and electrodermal activity (EDA), indicating higher arousal during in-person interactions, the t-test showed no significant differences in these physiological responses when compared to VR settings. This similarity in emotional responses, regardless of the interaction medium, supports the potential of VR to create a convincingly real experience for participants. The similarity in physiological responses across VR and in-person settings might suggest that VR is sufficiently immersive to elicit real-world emotional and physiological reactions. This supports the concept of "presence" in virtual environments, where the user feels genuinely immersed in and affected by the virtual space as though it were real [26].

While physiological responses did not differ significantly between settings, subjective reports highlighted variations in comfort and emotional reactions. These variations emphasize the limitations of using physiological data alone to assess emotional states. Our study demonstrates the importance of a multifaceted approach that incorporates physiological data, subjective feedback, as well as audio and observational analysis. This approach allows for a more nuanced understanding of how VR affects individuals with social anxiety, especially considering that spikes in HR and EDA were often accompanied by reports of positive emotions, suggesting a complex relationship between physiological arousal and emotional perception.

VR removes many communication cues present in real-world settings, such as physical presence and eye contact, reducing anxiety and allowing individuals to focus on the essence of interaction. One participant noted that, “There were other things to distract me in VR. I could look at the background or the avatars when anxious with a lull in conversation while in person. it was only me and the person with no distractions and it felt more awkward.” Our study found that in some instances, the VR environment has the ability to decrease discomfort and enhance the therapeutic experience by offering users control over their virtual surroundings. VR's ability to customize environments for specific therapeutic needs enables practice in a safe, controlled space, boosting confidence and skills transferable to real-world situations. Consequently, VR proves to be an invaluable tool in social anxiety therapy, improving accessibility and effectiveness of interventions.

Based on our observations, signs of nervousness were more apparent during in-person sessions. This reduction in VR may be attributed to participants engaging their hands with controllers, providing them with a distraction. Notably, leg shaking - a behavior often associated with anxiety, restlessness, or discomfort - was prevalent among some participants during in-person interactions. Despite these observations, survey responses indicated that participants felt comfortable during the in-person discussions. This discrepancy raises several questions: Are feelings of comfort and anxiety mutually exclusive, or can they coexist? Could anxiety have been present but not strong enough to overshadow feelings of comfort? Alternatively, were participants possibly less forthcoming in their survey responses? This contrast underlines the importance of contextualizing behavioral observations with self-reported data to gain a fuller understanding of participants' experiences. VR possibly offers a distraction from anxiety through physical engagement like hand movements, which might help those prone to fidgeting.

Given that participants consistently felt comfortable in both the in-person and VR settings, this suggests that VR could hold potential therapeutic benefits [1]. The ability of VR to simulate a controlled yet immersive environment may help individuals practice social interactions in a safe space. This could be particularly beneficial for those with social anxiety, as VR can offer gradual exposure to social stimuli and allow for the development of coping mechanisms in a manageable, customizable setting. Additionally, the comfort levels we found supports observations made during the COVID-19 pandemic, where video games and VR were utilized as substitutes for in-person communication [23]. This trend demonstrated that digital platforms could effectively replace face-to-face interactions, providing essential social engagement at a time when traditional methods were not possible.

Implications

Our findings highlight the potential of virtual reality (VR) as a therapeutic tool in the context of increasing rates of social anxiety and depression around the world [27]. The data suggest that experiences and emotional responses in VR closely mirror those in real-life interactions, possibly even offering a more comfortable space for users. This indicates that VR could serve effectively as a form of therapy, providing a safe, controlled environment that might ease the symptoms of social anxiety.

The COVID-19 pandemic highlighted the challenges of maintaining social interaction during extended periods of social distancing and isolation. Our findings indicate that virtual reality (VR) can effectively mimic real-life social interactions, suggesting its significant potential utility in similar future scenarios. Unlike traditional digital communication platforms, which primarily involve audio and visual interaction, VR offers a more immersive experience that can engage multiple senses and create a sense of physical presence and space. This immersive quality makes VR uniquely suited to replicate the nuances of face-to-face interactions, thus potentially reducing feelings of isolation and promoting better mental health.

Limitations

While our study provided insightful findings and expanded the body of research on the physiological and psychological impacts of virtual reality in social interactions, it also faced several limitations that may affect the interpretation and generalizability of the results.

Our study involved just the four participants making it a relatively small cohort to get statistically significant results. Our results might not hold true for a larger group of people. We also faced limitations because we couldn't record videos due to privacy regulations, preventing us from capturing crucial non-verbal cues that are essential for fully understanding social interactions. The sequence of our sessions, with in-person discussions before virtual reality experiences, could have introduced a bias that affected how we reacted and the physiological data we collected. We also encountered equipment issues; for example, the device Sam used to measure emotional responses malfunctioned and consistently showed lower readings. Moreover, our frequent hand gestures might have interfered with these measurements, potentially skewing the data. Since our study was quite short, it's also possible that we couldn't observe enough to make strong conclusions about our behavior and responses in the study setting.

5 Conclusion & Future Works

Our study demonstrated that both in-person and VR experiences can elicit similar physiological and emotional responses, suggesting that VR is sufficiently immersive to replicate real-world interactions. However, it is crucial to consider the context when analyzing physiological data, as emotional valence is not always clear through analysis of physiological data alone.

The findings advocate for the use of VR in therapeutic settings, especially for exposure therapy aimed at treating social anxiety. VR's ability to simulate realistic social interactions in a controlled, less threatening environment can help individuals acclimate to stressful social situations, potentially improving psychological well-being and offering a new avenue for treatment strategies.

Our results also corroborate previous studies that identified VR and video games as beneficial social supplements during the pandemic, reinforcing the versatility and utility of digital platforms in maintaining social connectivity. While our study has provided valuable insights, more work is needed to gather more accurate results and better understand how VR can impact therapeutic outcomes in psychological research. One recommendation for future research is to standardize the methodology for evaluating physiological data in conjunction with observational and self-reported data. Our findings suggest that a deeper contextual understanding is essential for accurately interpreting physiological responses. To effectively correlate physiological data with emotional states, further refinement and standardization in research methodologies are necessary. We also recommend that future studies include a larger and more diverse participant pool. This approach ensures that results are relevant across various demographic groups and helps understand how different populations respond to the same conditions or treatments. Expanding the dataset not only improves the generalizability of conclusions but also helps identify unique responses and refine therapeutic methods based on broader demographic insights.

In the post-VR survey, participants reported that while VR felt similar to in-person interactions, it also evoked a somewhat "unreal feeling" and they were not able to “focus on the avatar’s facial expressions.” This unreal feeling or sense that something isn’t quite right could be a reference to the “uncanny valley” phenomenon which occurs when avatars in VR or other digital forms are aiming to be lifelike but slightly miss the mark, creating a feeling of uneasiness [22]. To make VR experiences more lifelike, we recommend enhancing VR avatars with more advanced facial features and body language. This improvement would help create scenarios that more closely mirror real-life interactions, which can help foster a deeper sense of immersion and realism, ultimately enhancing user comfort and the overall effectiveness of the VR experience.

Additionally, other future work should include long-term studies. Long-term studies are vital for understanding the similarities and differences between in-person and VR interactions. By observing users over time, researchers can see how perceptions and the effectiveness of VR evolve, uncovering potential long-term benefits or drawbacks. This extended analysis can also provide deeper insights into VR's lasting psychological impacts on behavior, social interaction, and emotional health.

Lastly, future research comparing in-person and VR scenarios in interventional studies, like exposure therapy, is crucial. This comparison can reveal how VR might differ from or surpass traditional in-person therapy. By analyzing patient responses in both settings, we can identify whether VR offers unique benefits, such as faster adaptation or reduced anxiety, thus refining and enhancing therapeutic approaches.

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