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Anonymous Panda
Preserving Anonymity and Expressiveness in Online Mental Health Platforms

MASTER DISSERTATION

Érica da Silva Freitas
MASTER IN INFORMATICS ENGINEERING

UNIVERSIDADE da MADEIRA
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Abstract

Digital solutions that allow people to seek treatment, such as online psychological interventions and other technology-mediated therapies, have been developed to assist individuals with mental health disorders. Such approaches may raise privacy concerns about the use of people's data and the safety of their mental health information.

This work uses cutting-edge computer graphics technology to develop a novel system capable of increasing anonymity while maintaining expressiveness in computer-mediated mental health interventions. According to our preliminary findings, we were able to customize a realistic avatar using Live Link, Metahumans, and Unreal Engine 4 (UE4) with the same emotional depth as a real person. Furthermore, these findings showed that the virtual avatars' inability to express themselves through hand motion gave the impression that they were acting in an unnatural way.

By including the hand tracking feature using the Leap Motion Controller, we were able to improve our comprehension of the prospective use of ultra-realistic virtual human avatars in video-conferencing therapy, i.e., both studies helped us understand how vital facial and body expressions are and how problematic their absence is in communicating with others.

Keywords: virtual human · empathy · anonymity · assistive technologies · mental health · online self-disclosure

Resumo

Soluções digitais que permitem às pessoas procurar tratamento, tais como terapias psicológicas online e outras terapias com recurso à tecnologia, foram desenvolvidas para ajudar indivíduos com distúrbios de saúde mental. Tais abordagens podem suscitar preocupações sobre a privacidade na utilização dos dados das pessoas e a segurança da informação sobre a sua saúde mental.

Este trabalho utiliza tecnologia de ponta em computação gráfica para desenvolver um sistema inovador capaz de aumentar o anonimato, mantendo simultaneamente a expressividade nas intervenções de saúde mental mediadas por computador. Segundo os nossos resultados preliminares, conseguimos personalizar um avatar realista usando Live Link, Metahumans, e Unreal Engine 4 (UE4) com a mesma profundidade emocional que uma pessoa real. Além disso, os resultados mostraram que a incapacidade dos avatares virtuais de se expressarem através do movimento das mãos deu a impressão de que estavam a agir de uma forma pouco natural.

Ao incluir a função de rastreio das mãos utilizando o Leap Motion Controller, conseguimos melhorar a nossa compreensão do uso prospetivo de avatares humanos virtuais e ultrarrealistas na terapia de videoconferência, ou seja, os estudos realizados ajudaram-nos a compreender como as expressões faciais e corporais são vitais e como a sua ausência é problemática na comunicação com os outros.

Keywords: humano virtual · empatia · anonimato · tecnologias assistivas · saúde mental · online self-disclosure

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List of Acronyms

AE Affective Empathy

AFI Anticipated Future Interaction

CE Cognitive Empathy

CMD Chest Mounted Display

DDC Display Data Channel

DMD Desktop Mounted Display

FABRIK Forward And Backward Reaching Inverse Kinematics

HMD Head Mounted Display

LOD Level of Detail

OPD Online Public Disclosure

PA Perceived Anonymity

PEU Perceived Ease of Use

PU Perceived Usefulness

SP Social Presence

TAM Technology Acceptance Model

UE4 Unreal Engine 4

UI User Interface

VA Virtual Avatar(s)

VBO Virtual Body Ownership

VC Virtual Character(s)

VH Virtual Human(s)

VR Virtual Reality

Vtubers Virtual Youtubers

XR Extended Reality

1 Introduction

In the last few years, people have been increasingly struggling with mental illnesses and related disorders [4,5]. Many of todays' cases might be related to the COVID-19 global pandemic. While the economic impact of social isolation and quarantine has been estimated, the number of infections has continued to climb, with cases and deaths rising in many places [6–8]. The disease's direct consequences on individuals and their families and its indirect implications on financial security, housing, unemployment, and social isolation have led to an increase in emotional and psychological issues around the world, with particular communities being disproportionately impacted [6–8]. Worry, stress, anxiety, and other emotional responses are common in times of uncertainty [9–11], however they can intensify the symptoms of those already who have a mental illness. Another issue for people with mental illness during the pandemic is that social isolation makes getting appropriate mental health care more challenging. Furthermore, mental illness is associated with a cultural stigma, making people reluctant to seek care, which can increase feelings of loneliness and isolation [12].

1.1 Motivation

A convenient and growing solution, especially during the COVID-19 pandemic [13–15], for supporting mental health patients is the use of videoconferencing systems. However, this convenience might be problematic for mental health because patients' privacy and anonymity must be maintained. Moreover, the patient himself could become more stigmatized with the videoconference technology [16, 17] and could feel less prone to expressing their feelings, leading to more significant difficulties from the therapeutic perspective. On the other hand, to maintain privacy and anonymity, the patients can resort to text therapy or even phone consultations [18–22]. Patients and counselors may find these types of treatment convenient, but they are no match for face-to-face interactions since both patients and therapists do not have access to nonverbal cues, which are an important part of diagnosing the problem [23, 24].

The most difficult step for someone suffering from depression and/or anxiety is accepting and dealing with their situation, as well as seeking help to overcome it, so the support via video conference that emerged during confinement facilitated this part. However, there will always be people who do not feel comfortable revealing their true selves since they are afraid of being judged due to the nature of their problems and the social stigma that exists throughout the world.

This dissertation presents the development of the Anonymous Panda, a working prototype capable of anonymously connecting people with mental health specialists to overcome the lack of confidentiality and security on videoconferencing therapy and the lack of expressiveness of text/phone therapy. Anonymous Panda manages to overcome these barriers with the introduction of ultra-realistic virtual human avatars, the Unreal Engine Metahumans [25, 26]. These Metahumans are very recent avatars that provide a very high level of realism but require a very high graphics computational level, which unfortunately is not available to everyone. Despite this, these avatars achieve greater anonymity while retaining the expressive capabilities of a standard videoconference, making them the ideal solution for people who do not feel comfortable revealing their true selves due to the fear of being judged and the social stigma that exists globally.

1.2 Contributions

This work offers a three-folded contribution to both the virtual reality research field as well as supportive technologies:

(i) a new videoconferencing prototype that tracks facial positions and expressions, hand gestures, and uses ultra-realistic human avatars in 3D and real-time, applied to the context of mental health videoconferencing;

(ii) an updated body of knowledge regarding how people perceived ultra-realistic avatars, in this case the metahumans, and how they might emotionally affect them;

(iii) a new body of knowledge regarding people's behavioural attitudes and intentions towards using such a system in the future, with a particular interest in how people balance anonymity and expressiveness.

1.3 Research Questions

In the pursuit of human happiness and well-being, it is critical to assist individuals in being more honest. This purpose has contributed to the development of a new type of assistive technology, one that employs virtual avatars (VA) to assist patients in opening up and connecting more deeply and honestly with mental health professionals. The following questions have arisen in order to comprehend the benefits of using VA in mental health therapy:

[RQ$_1$] - Can virtual avatars elicit the same emotional response as human-to-human interactions?

[RQ$_2$] - Can virtual avatars help promote interactants' verbal self-disclosure?

Answering these questions is important because they can help us understand how metahumans can support people in opening up and interacting with others more honestly.

Although other researchers have addressed questions similar to ours [27–34], these research questions are essential since the VA used in this experiment are new and underexplored. Furthermore, they exhibit more realistic human traits than other works [27–34], implying that the findings of similar works cannot be considered to be valid because the conditions are distinct.

1.4 Document structure

Following the contextual analysis, a literature review was developed, which contains subsections for expressiveness and realism of VA, anonymity issues in virtual avatars, the combining and tradeoffs between expressiveness and anonymity, and finally other approaches related to VA. When the state-of-the-art workflow was drafted, each subsection was compared and correlated with the proposed solution.

The first prototype is shown in Chapter III. This chapter describes how it was constructed and which metahumans were chosen, as well as how it works with video conferencing tools, how it identifies human facial expressions, and some of the prototype's limitations. Finally, it goes over the verification of the prototype's viability in great detail, including a description of the participants and procedure, as well as how the study was evaluated, providing results as well as some analysis of the findings.

Chapter IV shows a new updated prototype that emphasizes the role of gestures when speaking. This chapter goes into considerable detail about the implementation of hand tracking, as well as some of the prototype's issues and limits. Additionally, the new UI prototype was included. Last but not least, it covers in great detail how the viability of the prototype was verified. This includes a description of the participants and procedure, as well as how the study was evaluated, providing results and some analysis of those results. Then, Chapter V discusses the study's conclusions and future work.

2 State of the Art

Although the use of avatars appears to be a relatively new concept, it has long been studied by other researchers. These avatars can be found in a variety of contexts, but they are most commonly used as entities with whom the user can interact. This thesis, on the other hand, aims to use an avatar that will be controlled by a user through expressions and facial movements in order to interact with other people confidentially. In addition to facial expressions and movements, hand gestures play an important role in communicating with others. We could only understand this limitation through the gathered feedback because there were few studies that addressed the worth of hand gestures via avatars in virtual realities.

The main topics addressed in terms of the state of the art were mainly related to the use of avatars in mental health treatments, but none was completely related to the theme of this dissertation. As a result, we ended up exploring other approaches to avatars that were focused on realism, anonymity, the impact it would have on users, and expressionism, for example.

2.1 Expressiveness and Realism of Virtual Avatars

Face-to-face interactions are hard to replicate online; however, today's technology allows us to create avatars that can display an array of human emotions. These virtual characters are increasingly being employed to facilitate interactions in various contexts [35], from health-care to education, we are beginning to see an increase in the use of virtual agents as a means for people to learn complex tasks or improve their knowledge and experience [36, 37]. One interesting area of research is using virtual avatars in health-care. For example, Zalake et al. [28] have shown that computer-generated simulations are effective in increasing trustworthiness. Their experiment aimed to understand if the appearance of a virtual avatar affects users' trust and willingness to engage in future encounters with them. Twelve adults participated in the study and interacted with a virtual avatar (physically represented by a computer-generated head and body). This avatar was formally dressed in one setting, while the other was informally dressed. They looked at the participants' self-reported trust levels and eye fixation duration on the virtual human's face during the experiment. There was no statistical difference in eye contact or trust between the two test settings, indicating that the users' trust levels were unaffected by the physical attire of the virtual avatars.

Also related to physiognomy, a recent study by Milcent et al. [38] aims to determine if recognizing basic emotions on an expressive virtual human (VH) is as effective as recognizing basic emotions on an actual human using expressive wrinkles and pupillary size. Furthermore, expressive wrinkles have an impact on emotion recognition. Even though the impact of pupillary size is not as strong, they believe that both are necessary for creating an expressive virtual person. Still, what if virtual humans can be more engaging than real ones? Gratch et al. [29] showed that a simple virtual avatar with positive listening feedback could elicit the same rapport-like effects than human-to-human contact. Rapport techniques are a concept of psychology that allows us to establish a connection of tuning and empathy with another person by demonstrating that his or her point of view or values is understood and respected. The rapport in this study is based on irrational feedback, which means that the avatar does not understand the meaning of the speaker's narrative but exhibits support for the user's point of view through nods. While this type of input can be rather useful and help us understand the connection with virtual humans, it is insufficient for most VH applications since it does not provide accurate feedback.

In a distinct context, but one that is nevertheless connected to physiognomy, Latoschik et al. [39] were interested in how realistic avatars affect users in a virtual environment. There were two types of avatars in their experiment: realistic and abstract. The realistic avatars were created using the previously mentioned methods, while abstract ones were based on a wooden dummy. To assess the effect of avatar realism on self embodiment and social interaction quality, both avatar representations were alternatively applied to participating users and the virtual counterpart in dyadic social interactions. Then, participants' acceptance of virtual body ownership (VBO) was tested for both types of avatars and whether the appearance of other people's avatars impacts the users' self-perception. The findings imply that realistic avatars are viewed as significantly more human-like when employed as representations for other persons, leading to a higher level of VBO acceptance. There was also evidence that users' self-perception is affected by the design and appearance of other people's avatars.

When it comes to presenting virtual avatars in realistic scenarios with high visual fidelity, Kang et al. [32] believe that presenting virtual humans via mobile phone video chat services does not seem to affect how people feel and relate with the VH in contrast with connecting to a real person. So, they were interested in whether making the background more or less realistic would make any difference. Their results indicate that having a realistic background had no significant effect on the perception of any variable while having no background made the virtual human seem less natural and more appealing to women but not men.

Regarding the same scope, Kang et al. [40] conducted another experiment to understand if people were motivated to stay engaged longer in a conversation with a VH on their smartphones if it had high visual fidelity. The study results showed that low visual fidelity had little effect on engagement rates, and although people preferred a 3D animated character over a regular video character with less synchronized backchannels, they still expected the video character to be real because they believed it was a person's video.

Finally, in order to understand how the empathetic potential of virtual avatars could be explored and how well they could engage live audiences, Zelenskaya and Harvey [41] also studied the responses of the general public during an experiment. The experiment was made possible by a low-cost multimedia set-up that utilized the most recent developments in real-time motion capture technology to enable a human actor to operate the 3D avatar Paige and interact with a live audience. Paige seemed to create a great first impression and gained more attention after a few short encounters. Many visitors were afraid to engage in a deeper dialogue, but most were interested in meeting the talent behind the scenes. Finally, observational data collected at the end of the study showed that some people would rather develop a human relationship first than communicate with a virtual character (VC).

2.2 Anonymity Issues in Virtual Avatars

Virtual worlds and online interactions have their own set of social dynamics. Users are not as visible or accountable for their actions in these virtual environments as in face-to-face contexts, and they can choose to be anybody they want. This phenomenon can be highly beneficial for persons dealing with particular emotional challenges, since it can provide them with a chance to express themselves in ways they would not ordinarily be able to in their daily lives [16, 30, 31].

However, in these virtual environments, those with ill intent might exploit the lack of accountability, often known as the "disinhibition effect" [42, 43]. In today's world, this is a common

occurrence. Because of the internet, children and adults have spoken inappropriately and even bullied others, claiming to be safe behind their screens while forgetting that they're just as vulnerable to harm. But, emphasizing the positive side of anonymity, can virtual humans promote verbal self-disclosure from people suffering from mental illnesses and related disorders? For example, Kang et al. [44] demonstrate that VH significantly improved the behavior of socially anxious interactants. The authors found that people with high social anxiety had greater behavioral rapport and communicated more than those with low social pressure in response to contingent non-verbal input from virtual beings (rapport agents). This shows that if interactants have high levels of social anxiety, rapport feelings may hinder personal self-disclosure, which needs further investigation in future research.

On the other hand, can the anonymity associated with virtual humans encourage people to share information? According to Lucas et al. [30], VH can improve readiness to reveal in a clinical interview scenario. They show that virtual humans can have this effect by giving patients the feeling that their responses are not being judged. They infer that VH interviewers' ability to extract more honest answers derives from the perception that no one monitors or evaluates them throughout the interview. The only difference between frames was the impression that another human was watching reactions during the interview. According to these results, a significant barrier to acquiring trustworthy patient data might be overcome with the aid of automated virtual persons. Others intruding on people's privacy is the last thing they desire. However, the tendency towards online self-disclosure is altering our lifestyles [45]. Even if we do not like it, we can not stop expressing ourselves online. Understanding how and why users divulge personal information in online social spaces, as well as their perceptions of online privacy, is an essential research agenda in human-computer interaction.

In Social Virtual Reality (i.e. a type of online social interaction that uses immersive technology and takes place in three-dimensional virtual worlds where users, represented by avatars, may participate in real-time interpersonal dialogue and shared activities), Maloney et al. [46] focus on the kind of information users reveal and who they disclose it to, and their concerns about self-disclosure. According to their research, users can display their emotions, experiences, and personal info in Social Virtual Reality. Participants understood that providing personal information in Social Virtual Reality was an unavoidable trade-off for turning over biometric data to improve the system. Some respondents saw providing information as having no privacy implications, while others were concerned about the scope and content of what they supplied. According to the researchers, these findings will help them in better understanding self-disclosure and privacy concerns in Social Virtual Reality, as well as potential solutions for building safer and more pleasurable Social Virtual Reality platforms.

Finally, avatars in Virtual Reality (VR) for teletherapy may combine the benefits of face-to-face conversation with the anonymity of online text-based communication. Baccon et al. [34] attempted to determine if immersive virtual reality can encourage self-disclosure and, as a result, better communication. Their research is the first to contrast the frequency of objective and perceived self-disclosures amongst dyads that chatted in person, virtual reality, or online text-based circumstances. The authors also present an entirely new paradigm of VR research and kick off a conversation about how to use VR to foster relationships. Their research suggests that using avatars in virtual reality could be as practical as face-to-face communication in boosting self-disclosure. As

a result, since avatars allow us to combine the benefits of face-to-face contact with the anonymity of over-the-top communication, VR could be a good tool for teletherapy.

2.3 Combining And Tradeoffs between Expressiveness and Anonymity

We have various expression tools in today's online world, such as blogs and forums. However a lot of them are cumbersome or lack expressiveness. Avatars offer imaginative worlds where people can be whatever they want to be, bring new forms of self-expression to the web, and create better ways to talk about themselves online. They are an exciting and promising new way to express yourself and connect with others. Virtual Youtubers (VTubers) are an outstanding example of this since they enable a customized animated virtual avatar that captures the user's facial movements and controls the avatar's facial expressions [27]. "Vtubing" originated in China and has moved to Japan, Taiwan, and Korea, although VTuber videos can be found worldwide. The most noticeable difference between a VTuber and a regular YouTuber is that the former expresses himself through computer-generated moving images and sounds, while the latter often appears in the videos. As previously stated, Lu et al. [27] confirm that Virtual YouTubers, or human-voiced virtual 2D or 3D avatars, are gaining popularity as live streamers in East Asia. Despite prior research indicating that many viewers want real-life interpersonal contacts with real-person streamers [27, 47], the authors performed an interview study to better understand how viewers interact with VTubers and how they interpret the identities of the voice actors that voice the avatars. According to the study, virtual avatars present a variety of performance opportunities, which leads to a wide range of spectator expectations and interpretations of VTuber behavior. With this in mind, the actors realized that audiences are more willing to tolerate impractical or foolish human behavior. As a result, they purposefully differentiated their VTuber avatars from their voice artists. Based on the findings of this study, we believe that, in settings other than streaming, expressiveness and anonymity can coexist. Thus, even though more unrealistic avatars promote tolerance for inappropriate behavior, they might also encourage ease on the mind of the avatar user.

But can we empathize with a computer-generated character, and, if so, how do similar affective responses differ between encounters with real people and interactions with a computer-generated figure? According to the latest study of Kang et al. [33], engaging with virtual characters can boost social interactions or help those who have difficulty developing social bonds develop social skills. The purpose of this study was to investigate the effect of avatar realism and interactants' anticipated future interaction (AFI)—condition that occurs when individuals who have had an initial interaction expect to meet again in the future—on self-disclosure in emotionally engaged and synchronous connections. Preliminary findings suggest that the linguistic behaviors of interactants revealed more personal information about themselves in virtual persons than in real humans. However, the AFI of interactions had no effect on self-disclosure, which contradicts prior research employing text-based interfaces.

In a similar context, but with the use of mobile as a means of communication, Kang et al. [48] investigate the effect of various avatar realism levels on the three types of social copresence—psychological copresence, social richness of the medium, and interactant satisfaction with communication—as well as the social communication quality of employing anonymous avatars during small-screen mobile audio/visual interactions. Their results show that, when using a simulated mobile device, hight levels of avatar kinetic conformity (the degree to which the avatar's dynamic movement reflects the expected motion of the object that the avatar appears to be) and fidelity

(visual quality of the avatar image) resulted in an increase of perceived social richness of medium (the user's perception of the communication medium's social and emotional skills). More robust degrees of Psychological Copresence and Interactant Communication Satisfaction were connected with higher avatar Anthropomorphism. On the other hand, increased avatar anonymity resulted in lower levels of Social Copresence. These impacts were lessened when avatars' visual and behavioral realism levels were higher.

Finally, Bigand et al. [49] investigate the movement of virtual signers, focusing on the concepts of physical mobility and anonymity. The authors propose that an avatar be organically animated and feasible by utilizing motion models to establish perceptual acceptance. This acceptance can be ensured by employing motion capture devices to capture and transform natural movements into an avatar. Non-linguistic information may be sent by precise systems, such as the signer's identity. To address this, the ideal answer would be motion models or procedures that could hide the signer's identity while preserving linguistic information and allowing for as natural a motion as possible. However, it would be difficult to determine the movement parameters that convey essence to manage them, and we are far from having the necessary expertise.

2.4 Other Approaches

Although not directly related to the context of this thesis, the following approaches have a significant role in understanding tools based on the use of avatars. A telexistence system (system that allows a human user to operate in an environment without physically being there) based on virtual avatars called AVATAREX is one of the methods. AVATAREX connects persons who are in the same physical place with their virtual counterparts. Koskela et al. [50] investigated how users experienced co-presence in a telexistence system based on virtual avatars using an indoor prototype version of AVATAREX and a basic collaborative game, as well as the performance of AVATAREX on high-end smart glasses. Users wearing VR gear reported a better sense of coherence than users wearing augmented reality gear, according to their findings. Surprisingly, users of augmented reality smart glasses reported a lesser sense of co-presence than those who used a tablet.

The other approach is virtual reality therapy facilitated by the use of avatars. Using a Microsoft Kinect camera in virtual settings, Benrachou et al. [51] proposed an innovative framework capable of collecting and replicating human-like gestures in real-time. Their work is centered on avatars monitoring human posture failures in order to improve people's posture throughout the healing stages (victims of stroke or mobility impairment). These scenarios include real-world motion capture data, which aids in the resolution of postural difficulties in patients at different stages of rehabilitation. Patients could take part in functional tasks that a physiotherapist designed and replicated as a serious game in a VR-based application. These demanding games were overseen by rehabilitation aids, who used gesture control to set the speed of their exercise regimen. In this situation, physiotherapists or rehabilitation aides should be present to ensure that the study is replicated as accurately as possible under favorable settings for patient rehabilitation. Experiments show that the proposed model is adaptable, and they were able to created various situations in order to allow an in-depth analysis of patients' movements via avatars.

Finally, regarding virtual human support agents, Rizzo et al. [52] created the SimCoach project, which intends to construct support agents to serve as online guides for encouraging access to psychological health-care information and supporting military members and relatives in breaking down

barriers to seek health-care. The experience was designed to drive users to take the initial step and to urge them to take the next step toward finding other, more official resources if necessary. However, while the VH were supposed to use speech, gesture, and emotion to explain their capabilities, solicit basic anonymous background information, provide advise and support, lead the user to relevant online content, and potentially simplify the process of obtaining appropriate care with a real clinical professional, their engagement with the user is limited because they receive input through chat messages.

2.5 Reflection

Although the use of virtual humans in mental health systems has still some limitations, such as the use of VH with mindless feedback [29], VH with written feedback [52], and the use of low fidelity avatars [27, 33, 34, 44], they still can provide new ways of interaction for people who want to benefit from anonymity. One of the goals of this dissertation is to create a mimicked image of a user and convey it to others as if it were the user themselves by employing a virtual human as an alternate self in real-time. While existing research on virtual humans mainly tries to simulate human behavior to create empathy with the user, our work takes this one step further by using cutting-edge technology to ensure anonymity and promote self-disclosure in the mental health domain. Through the real-time use of a ultra-realistic avatar in video conferencing, we argue if it is possible to maintain the level of expressiveness while preserving anonymity. Furthermore, by establishing a gap between the real and virtual selves during a video call, we are able to maintain a level of anonymity and expressionism that other forms of avatars used in other studies could not, with the exception of the Paige avatar [41], which aimed to investigate people's reactions during their experience as well as empathy and the ability to engage with a live audience, which in turn contributed in the investigation of virtual humans.

3 The Anonymous Face Tracking Panda

As previously stated, living with a mental illness can be isolating and the stigma around mental health issues makes people hesitant to seek professional help [12]. The primary purpose of this dissertation is to create a functional prototype capable of connecting people with mental health specialists anonymously, while still maintaining patient-therapist empathy.

3.1 Approach

A working prototype was developed using Unreal Engine Blueprints (a node-based interface to create gameplay elements), the UE4, Metahumans, and Live Link connected to an iPhone's camera. In the prototype, patients can communicate with mental health specialists via video conferencing anonymously, as patient's smartphone functions as a virtual camera that allows the mental health practitioner to see the patient's facial expressions in real-time via a virtual avatar.

Using an Apple device with the TrueDepth sensor and the Live Link Face app, one can capture numerous facial tracking points by creating a depth map of ones' face while projecting and analyzing over 30,000 invisible dots, as well as capturing an infrared face image. The data collected by the Apple device and app is delivered to the UE4 environment via a directed internet connection maintained between the user's iPhone/iPad and the Unreal Engine. When data is received by Unreal Engine 4, it is evaluated and turned into VA movements via Live Link Plugin, as shown in Figure 1 and Figure 2.

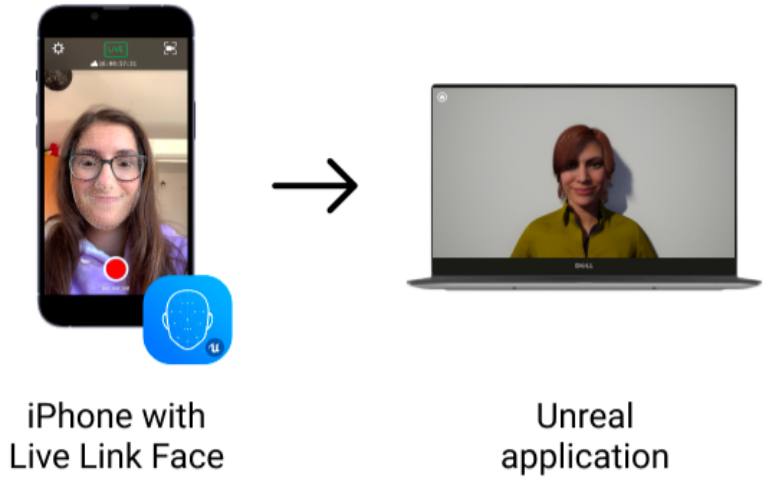


Fig. 1: How the facial expressions are captured and represented

The goal of the Live Link Plugin [53] is to provide a unified interface for streaming and consuming animation data into Unreal Engine 4 from one or more external sources, such as Display Data Channel (DDC) tools or Mocap Servers. It's built to be extensible via Unreal Plugins, allowing third parties to create new features without having to make and maintain Engine changes. Live Link can also be used by Motion Capture Systems to stream data into the Engine that can be previewed in real time.

To provide users with options, and thus reach a wider audience, four metahumans (two males and two females, of different ethnicities) were exported from the Metahuman Creator [25], and the

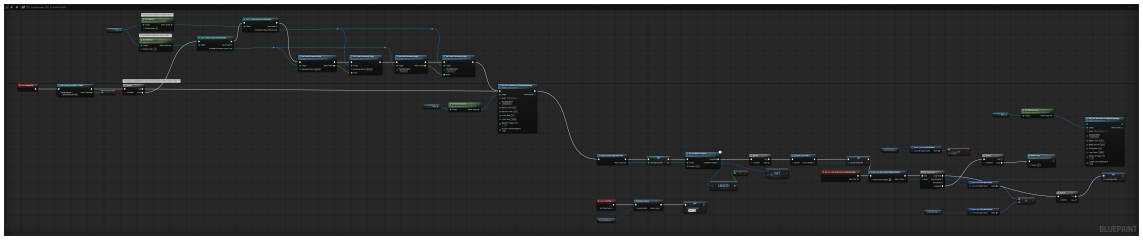


Fig. 2: Blueprints responsible for the connection and stream of data

Quixel Bridge application into UE4, where, in order to make the interaction with the prototype easier, a minimalist user interface (Figure 3) was created that allows users to choose their preferred avatar.

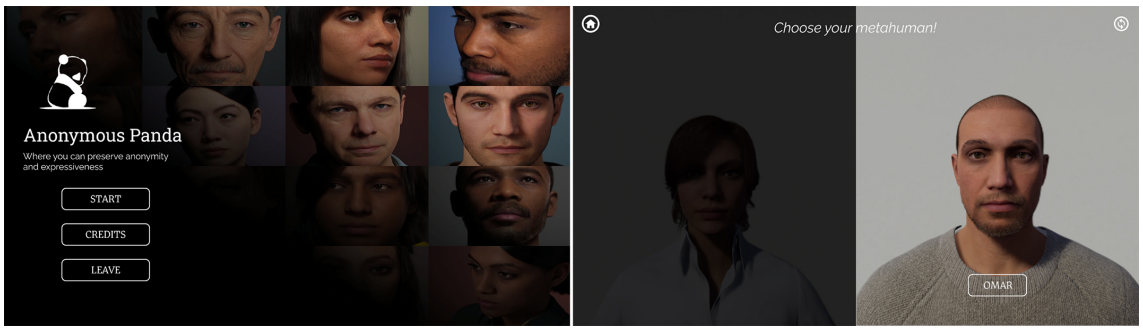


Fig. 3: Screenshots of the Anonymous Panda application

Although custom metahumans were not employed in this version of the prototype, due to performance and optimization concerns, the chosen metahumans (Figure 4) were pre-made by Epic Games and available on Quixel Bridge. These concerns were alleviated by using these four metahumans because Epic Games pre-defines export settings and assets compatible with many devices.

Fig. 4: The current metahumans used on the prototype

As the human face is the primary means of non-verbal communication [54–56], it is typically used to communicate a person's emotions and mood and to provide visual cues to a person's physical state. Facial expressions are easily distinguished across cultures and automatically perceived so

that we can immediately evaluate someone's emotional state. As Figure 5 makes visible, the facial expression of the VA are perceptible in the current version of the prototype.

Fig. 5: Examples of facial expressions and their virtual avatar depiction

However, upon a closer look, even though the avatar could accurately represent the user's facial expressions using the default functions of the live link plugin, a minor flaw in terms of lip positioning was found, particularly when the mouth should be closed or when the user was trying to express a negative emotion (e.g., sadness). To solve this issue, the upper lip values were slightly adjusted (Figure 6) before being reconverted to metahuman animation.

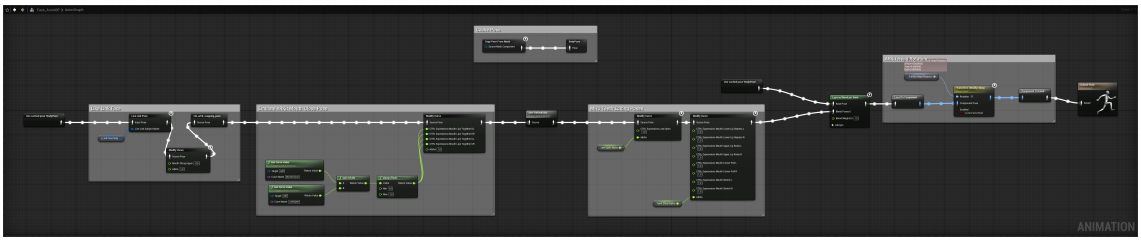


Fig. 6: Blueprints responsible for the conversion of data to animation of metahuman

Although one of the foundations of this dissertation is patient-therapist communication, the current prototype requires the user to share only the UE4 application as if it were a webcam, which necessitates the usage of a video conferencing tool as well as OBS Studio Virtual Camera, a live streaming tool (Figure 7 and 8). Even though this causes a slight delay, it can be used in a video conference.

3.1.1 Limitations

One of the dissertation's challenges is to use customized models because these models demand a lot of optimization. After all, they are resource-intensive, limiting the patient's expressions from being viewed clearly and fluidly.

Nonetheless, the creation and use of custom metahumans has already improved thanks to recent contributions from Epic Games. However, because many assets are still in development, the design and use of metahumans are still limited. Meaning, if these assets are excluded, it should be possible

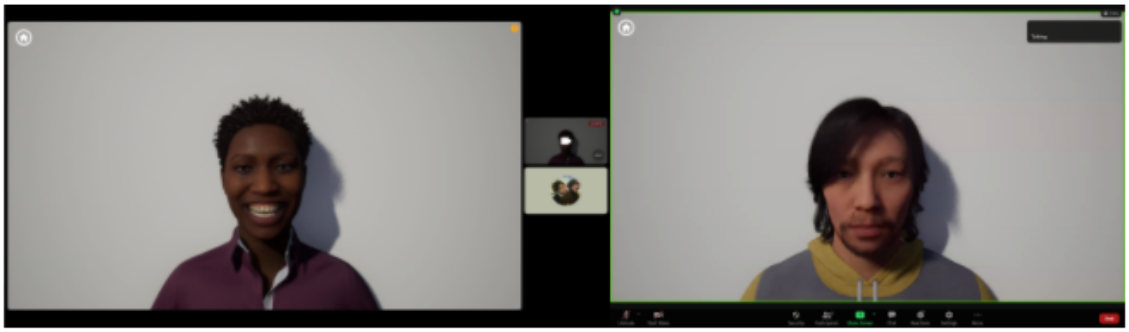


Fig. 7: The prototype in use on a call via Discord and Zoom

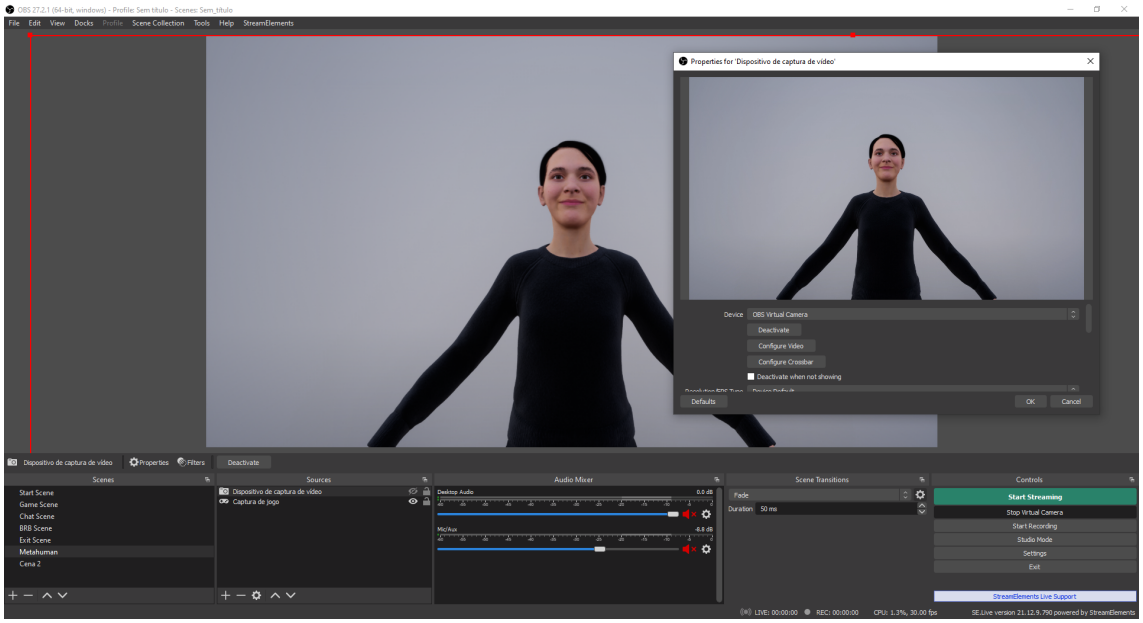


Fig. 8: Virtual Camera setup on OBS Studio

to use metahumans other than those pre-defined by Epic Games. Despite Epic Games' warnings about using a metahuman with groom elements in development, as well as only displaying it in Levels of Detail (LOD) 0 and 1, some users ignored the warnings and attempted to import a custom metahuman into their projects, resulting in mesh issues (e.g. can be seen in Figure 9). The many levels that make up each groom element's LODs set, which includes hair, mustache, beard, eye brows, eye lashes, and vellus (also called peach fuzz), are depicted in Figure 10.

Moreover, because this is a resource-intensive application, another difficulty is how people will utilize it. As a result, one of the problems is figuring out how to develop this program to reach everyone who needs it.

3.2 Methodology

To assess the feasibility of the previously described approach and test users' empathy with the metahumans, a controlled experiment was carried out to evaluated whether these virtual avatars are able to convey the same emotional depth as a real person ($\mathbf{RQ_1}$).

Fig. 9: Issues with using metahumans with developing elements

Fig. 10: Groom LoD sequence from cinematic (0) to the lowest (7) quality

We conducted a between-subjects experiment to assess if our independent variable stimulus—which has three levels, metahuman (G_1), real person (G_2), and transcript (G_3)—had an effect on participants' cognitive empathy (CE) and affective empathy (AE). We also assessed whether the video had any effect on authenticity and social presence perceived by the participants. Each participant was exposed to the previously mentioned stimulus levels through the following randomly selected tests: a) pre-recorded metahuman, b) pre-recorded person, c) transcript from the previous pre-recorded contents (see Appendix A).

The metahuman was created to match the appearance of the real person (Figure 11) as close as possible while keeping performance levels high (by using only optimized assets). This was done in order to avoid introducing excessive third-variable bias [31], and as a way to balance the social presence levels in the metahuman and real person video conditions. The story was chosen from a specific *subreddit* (i.e., an online community where people ask others for advice) based on the amount of *upvotes* (1500) and number of comments (304) received on Reddit, as it provides a metric on user engagement and, therefore, we believe will help elicit empathy in the participants.

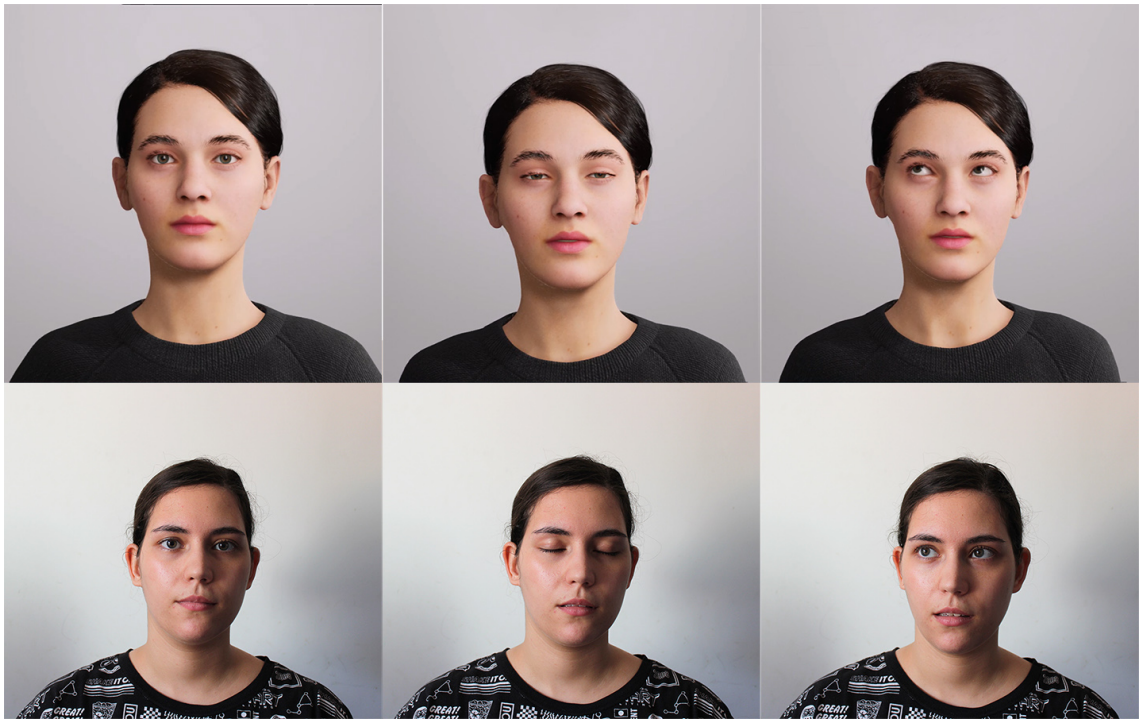


Fig. 11: Different expressions in both the custom metahuman and the actor

3.2.1 Participants

Participants were required to be at least 18 years old and needed to be college students. They were recruited via email and social media groups, and they were given a general overview of the study's topic. Our final sample consists of 48 college students (25 male, 23 female), aged between 18 and 45 (M=23.9, SD=5.7).

Those who agreed to participate (N=48) were first given an informed consent form. An independent samples design was used for this experiment, where participants were asked to fill out basic demographic questions and a self-assessment questionnaire [57] used to measure their baseline levels of empathy before our stimulus. Then they were randomly allocated to one of the three groups of content (G_1, G_2, and G_3) using an online random redirect tool [58] and finally, asked some follow-up questions.

Regarding the score for baseline empathy levels, they can vary from 0 to 64 [59]. Males tend to score in the range of 43.46 to 44.45 on this measure, while females tend to score in the range of 44.62 to 48.93 [59]. In comparison, the mean (M) scores in our study for males were 47.08, with a standard deviation (SD) of 5.54, whereas for females were 48.65, with a SD of 7.49, indicating that our male sample was slightly above average and our female sample was among the average results.

3.2.2 Procedure

To recruit participants, an online questionnaire was created and distributed through social media groups, along with emails spread to Madeira University's general student population. Participants (N=48) who agreed to participate in the study were first given an informed consent form and properly informed on the study's broad, general topic.

To prevent revealing the true goal of the experiment and thereby distorting the results, participants were asked to fill out basic demographic questions as well as some general questions about themselves from the Big Five Inventory [60] in addition to the Toronto Empathy Questionnaire [57]. They were then redirected to one of three groups of content (G_1, G_2, and G_3) through [58] before being asked to complete a questionnaire meant to assess participants' empathy levels in response to the randomly assigned stimulus, as proposed by [31, 61].

As mentioned before, for the pre-stimulus survey (see Appendix B) we used the Toronto Empathy Questionnaire [57], which consists of 16 items (e.g., "I become irritated when someone cries", 1=strongly disagree, to 5=strongly agree), as a control variable. Five items from the Big Five Inventory [60] were incorporated into the questionnaire to dispel any suspicions regarding the study's genuine goal.

Regarding the poststimulus questionnaire (see Appendix C and D), participants were requested to answer questions, related to cognitive and affective empathy (i.e., our dependent variable), on a seven-point Likert-type scale (1=totally disagree, 7=totally agree), based on the work of Bailenson et al. [62].

We used four questions to assess the video's perceived authenticity and social presence, presenting the statements: "I feel that the person is watching me and is aware of my presence", "The thought that the person is not a real person crosses my mind often", "The person appears to be conscious and alive to me", and "I perceive the person as being only a computerized image, not as a real person", with the above-noted Likert-type scale.

Then, empathy was tested in both video and transcript groups by using items adapted from the Interpersonal Reactivity Index [63] that deal with CE and AE. Three items were used to test CE: "I understand what made her get upset", "Her reactions to the situation are understandable", and "I understand her point of view". Afterwards three items were used to measure AE: "I can relate to her problem", "When I see someone in an unfair situation, I feel frustrated", and "I feel that her emotions are genuine".

Finally, participants could describe in an open-ended question what made them empathize and/or relate to the person in the video/transcription, as well as what they did not like.

3.2.3 Hypotheses and Statistical Analyses

To answer $\mathbf{RQ_1}$ (Can virtual avatars elicit the same emotional response as human-to-human interactions?), we tested if our independent variable stimulus—which has three levels, metahuman (G_1), real person (G_2), and transcript (G_3)—had an effect on participants' cognitive and affective empathy. Because the participants' CE and AE are supposed to indicate if the feelings and emotions conveyed via stimulus were understood, it's reasonable to assume that those with greater baseline empathy levels would comprehend the feelings and emotions better.

Therefore, our hypotheses were:

$\boldsymbol{H_1}$ - All stimulus conditions can elicit the same cognitive emotion.

$\boldsymbol{H_2}$ - The metahuman video stimulus can elicit the same affective empathy as the real person video stimulus.

$\boldsymbol{H_3}$ - The person video stimulus can elicit more affective empathy than the transcript stimulus.

To test $\boldsymbol{H_1}$-$\boldsymbol{H_3}$, we tried to see if the cognitive and affective empathy of each group differed significantly. This required a multivariate analysis method because we look at more than two variables (or factors) and how they might impact our experiment. As a result, we utilized the Kruskal-Wallis H test for ordinal, nonparametric data to see if there were any statistically significant differences in CE and AE between the three conditions.

We also wanted to investigate if the metahuman and real person groups' levels of social presence differed significantly. This required a bivariate analysis method because we only look at two variables (or factors). As a result, we used a Mann-Whitney U test to see if there were any changes in social presence between the metahuman and real-life video situations. Cronbach's Alpha was used to ensure the reliability of the cognitive and effective empathy items. Finally, all this data was analyzed in the IBM SPSS statistics software (v.28, 2021), using a statistical significance level of 0.05.

3.2.4 Results

To evaluate the differences in cognitive and affective empathy across conditions, we performed a Kruskal-Wallis test. The test showed no statistically significant differences in cognitive ($H(2)$=4.30, p=.116) or affective empathy ($H(2)$=.618, p=.734) for the three conditions (metahuman, n=23; real person, n=12; transcript, n=14). Table 1 show the results of the Kruskal-Wallis H test and Figure 12 show the independent-samples from the Kruskal-Wallis H test.

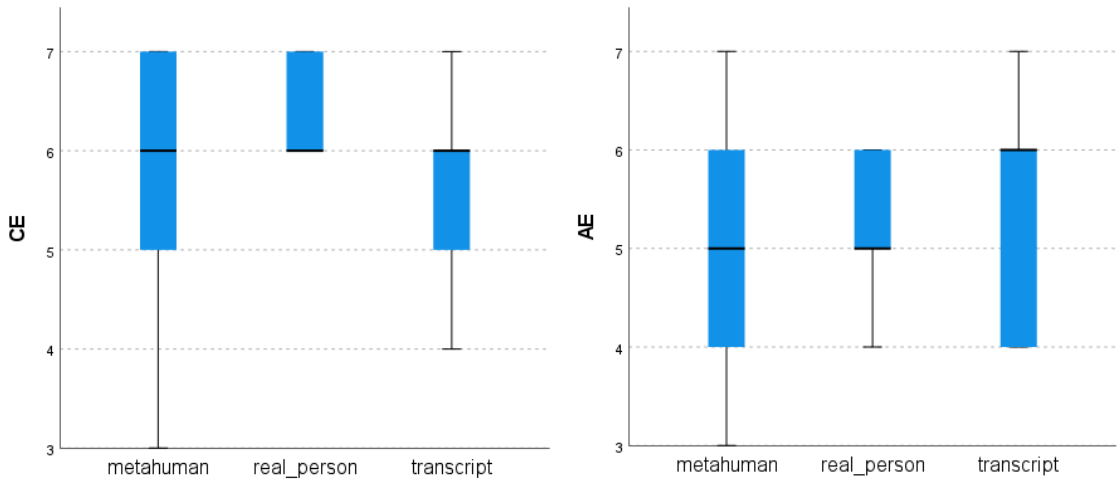
	CE	AE
Median	6	5
$H(2)$	4.301	0.618
p	.116	.734

Table 1: Results between G_1, G_2, and G_3

	SP
U	121.500
Z	-.192
p	.848
r	.004

	Metahuman	Person
Median	5	5

Table 2: Results between G_1 and G_2



(a) Cognitive Empathy

(b) Affective Empathy

Fig. 12: Independent-Samples Kruskal-Wallis

These results support our ***H₁***, namely that cognitive empathy is the same for all conditions. The same thing happened with our ***H₂***, where the metahuman video stimulus elicited the same affective empathy as the real person video stimulus. However, no statistically significant differences support our ***H₃***, which could imply that the person video stimulus elicited more affective empathy than the transcript stimulus.

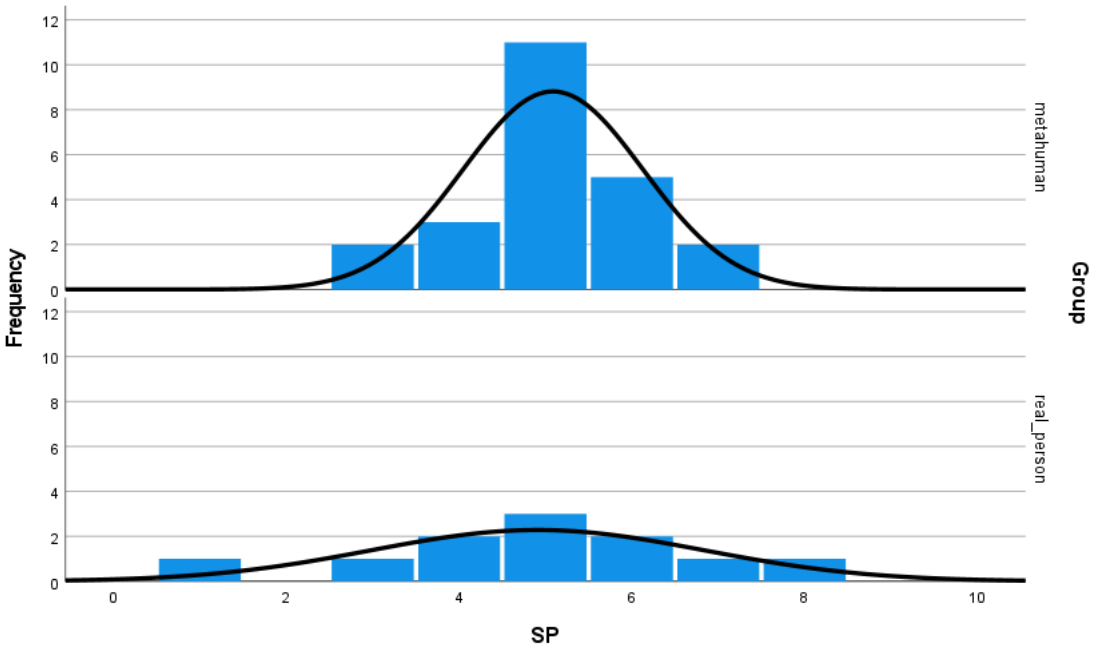


Fig. 13: Social Presence per group

To assess the difference in social presence between the two video conditions, a Mann-Whitney U test was also performed and the results are shown in Table 2. This test revealed no significant differences in social presence (U=121.500, Z=-.192, p=.848, r=.004) between the metahuman video (n=23) and the real person video (n=11). The frequency of social presence levels registered in the metahuman and real person conditions is represented in Figure 13.

Finally, the Cronbach's Alpha test reveals that the questions developed for evaluating CE and AE (α=.80) were appropriate for their purpose.

3.2.5 Qualitative Results

When reviewing and testing the Anonymous Face Tracking Panda prototype, we found that the virtual avatars' ability to express themselves was limited by the lack of hand movement, which made it seem unrealistic and similar to a puppet acting. Furthermore, some participants commented on the lack of body movement and how unrealistic the experience became, demonstrating that, in addition to the realism provided by the metahumans, something else was needed in this prototype.

3.2.6 Discussion

In this study, we were interested in whether metahumans could convey the same emotional depth as a real person (**RQ₁**). We wanted to test if our independent variable stimulus—metahuman (G_1),

real person (G_2), and transcript (G_3)—had any influence on participants' cognitive and affective empathy.

We found that all our conditions could elicit participants' cognitive empathy, which means that they were able to put themselves on the side of the storyteller and see the storyteller perspective. However, we can display cognitive empathy without feeling sympathy for someone because all we have to do is put ourselves in someone else's shoes to experience it. Recent research by Fernandez and Zahavi [64] on the ideas of emotional and cognitive empathy shows that none of these concepts adequately describe the most fundamental type of empathy. In their study, which looks into the role of empathy in nursing work, the authors claim that cognitive empathy enables nurses to comprehend their patients while keeping a professional distance and objectivity [64]. This supports what we previously suggested, which is that one does not have to feel sympathy for others in order to comprehend them. This means that, while the results confirm our $\boldsymbol{H_1}$, they could be easily skewed because we used a self-reported questionnaire, therefore there is a chance that individuals gave invalid answers [65].

Regarding our $\boldsymbol{H_2}$, we did not find significant differences in the level of affective empathy elicited by the avatar versus the real human. As a result, regardless of whether it was conveyed through the avatar or the real person, a self-disclosing story elicited similar levels of AE. Our findings support previous research on similar perceptions of avatars and human stimuli [31, 66]. We discovered a positive effect of authenticity on both cognitive and affective empathy, which supports our $\mathbf{RQ_1}$ that realistic avatars, in this case metahumans, may convey the same emotional depth as a real person. This may be interpreted as an indication that high authenticity enables the willingness to accept a different perspective and predict the internal emotional states of others. Another, more limiting interpretation is that the audio for each condition was kept consistent, and so voice was a strong carrier for the perception of empathy. Additional research needs to be done because we did not examine a limited situation with only voice or with altered voices.

Similarly, no significant differences were found in affective empathy between the person video stimulus and the transcript ($\boldsymbol{H_3}$). As a result, participants' levels of AE were similar whether they heard the narrative from the real person or read the transcript themselves. This could be related to the narrative itself, as it was chosen from a *subreddit* where people ask others for advice and it was a story that everyone can relate to as it is a typical everyday situation that could happen to any of us. Another interpretation might be based on how the person in the video portrayed themselves and how well it reflected the story's emotions because the participants were able to understand that person's circumstances and feelings, just as those who merely read the narrative did.

Finally, we evaluate the difference in social presence between the two video settings (metahuman and real person) in order to validate our $\mathbf{RQ_1}$ that realistic avatars may transmit the same emotional depth as a real person. Our findings revealed no significant differences in social presence between the metahuman video and the real person video. However, these results suggest that our avatars' level of realism can perform just like a real person would and thus be used as a webcam in video conference systems.

4 The Anonymous Face and Hand Tracking Panda

Given the metahumans' limited ability to express themselves due to a lack of hand movement, we wondered if the addition of hand tracking would improve the prototype and achieve a higher level of realism while still allowing the user to express themselves through the metahuman on different degrees. Furthermore, we wondered if this change would increase interactants' verbal self-disclosure ($\mathbf{RQ_2}$) and perceived usefulness.

4.1 Importance of Hand Gestures

When people speak, they typically make spontaneous hand motions that occur in synchronization with speech and naturally accompany all spoken communication; such movements are known as gestures [67]. Gestures serve a diverse range of purposes in communication, learning, and comprehension for those who see them as well as those who make them. Gestures are particularly successful when they resemble the thought they represent, giving them an advantage over words since they offer relevant and distinct information while reflecting the speaker's underlying knowledge and experiences [67, 68]. According to Feyereisen and de Lannoy [69], people of all known cultures and languages make gestures. Hence gestures are essential for making connections with others, although styles vary across countries.

Hand gestures, together with facial expressions and spoken words, play a vital role in communicating our feelings. To create emotional depiction, hand movements usually combine nontrivially with facial expressions [70]. It is well known that a person who uses his hands powerfully while expressing his opinions attracts far more attention than a person who only uses his voice to convey an idea [71, 72].

As previously stated, the primary purpose of this dissertation is to create a functional prototype capable of connecting people with mental health specialists anonymously, while still maintaining patient-therapist empathy. Therefore the addition of hand tracking is a critical step toward our goal in order to get deeper emotional recognition. Because, in addition to facial emotions and body posture, hands are the most significant nonverbal clues to identify specific states in others, such as anxiety states [73, 74].

Some studies suggest that nonverbal cues may be more reliable indicators of clinical conditions than patient verbal information [75]. For example, clinical psychology research has demonstrated that nonverbal behavior in human patients accidentally conveyed private personal details that were not provided in their spoken behavior [76, 77]. Nonverbal behavior, in general, plays a significant role in the formation and maintenance of a therapeutic connection in psychotherapy sessions through developing rapport between therapists and patients [77]—in other words, therapists spend a large amount of time and effort closely monitoring patients' nonverbal behavior and altering their own nonverbal behavior in order to respond successfully and build trust [78]. Furthermore, according to Abargil et al. [78], through the recognition of emotions, therapists are able to adjust therapy according to the patient's nonverbal and verbal cues, and thus obtain a better outcome. Another example demonstrates that while describing pain, co-speech gestures convey additional information beyond what is supplied in speech, perhaps making an important contribution to the communication of this experience and providing indications for improving therapy techniques and outcomes [74, 79].

4.2 Approach

Many studies claim that hand gestures, together with facial expressions and spoken words, play an important role in communicating our emotions. As a result, adding hand tracking to the current prototype is a vital step in achieving our goal of deeper emotional recognition, because hands, together with facial expressions and body posture, are the most important nonverbal cues for recognizing specific states (e.g., anxiety) in others [73, 74].

While there are a variety of ways to perform hand tracking, such as with virtual reality devices or gloves, we believe that the Leap Motion Controller is the best option for this thesis because it is a practical and small device that does not interfere with the face recognition part as it does not interfere with the TrueDepth sensor.

4.2.1 Leap Motion Controller and Unreal Plugin

The Leap Motion Controller (Figure 14) is a gadget that connects to a PC or a Mac and allows users to interact with virtual object with hand motions. When paired with other devices, it adds a new method to engage with the digital world. Gesture-based computer programs enable users to play games, develop, and learn in a hands-on environment. Using an infrared scanner and sensor, this system maps and tracks the human hand [1]. This data is used to generate a digital hand that can interact digital items in real time.

Fig. 14: Example of the Leap Motion tracking [1]

In order to connect the existing Anonymous Panda prototype with the hand tracking part, it was necessary to use the official UE4 plugin, the Ultraleap Hand Tracking Plugin [80]. This plugin allows Unreal developers to make use of the data obtained by incorporating Ultraleap's hand tracking data into their projects. It was designed with the intention of developing and implementing hand tracking in Extended Reality (XR) projects [81], but with the right adjustments, it was possible to adapt its use to other types of projects [82].

As previously stated, the Leap Motion Controller tracks hands and fingers with minimal latency and great precision, reporting position, velocity, and orientation. This controller is suitable for use with a VR headset or on a tabletop. The Leap motion Controller system, which operates as a

service or daemon, analyzes the images produced by its hardware and delivers the processed data to the project to combine Ultraleap's hand tracking data. The received data is then converted to the Unreal coordinate system by the Unreal plugin attached to the stated service [2]. Additionally, because the UE employs a left-handed convention for its coordinate system and centimeters as the default unit while the Leap Motion uses a right-handed convention and millimeters as the default unit, the plugin automatically converts the tracking data to utilize a left-handed coordinate system and scales distance values to centimeters [2]. The Unreal coordinate system is shown in Figure 15 in relation to the Leap Motion device in Head Mounted Display (HMD) mode.

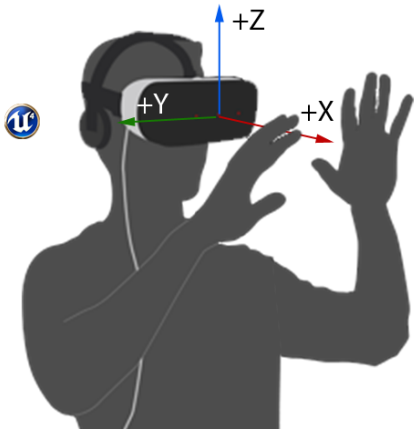


Fig. 15: Relationship of the Leap Motion device in HMD mode to the Unreal coordinate system [2]

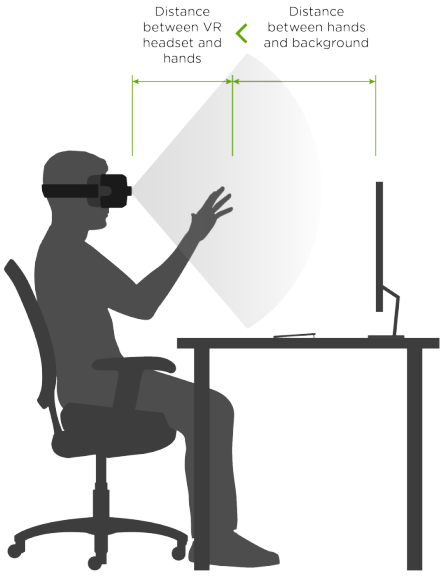


Fig. 16: In HMD mode, the sensor should be closer to the hands than the hands should be to any background objects or walls [2]

When the Leap Motion Controller has a high-contrast view of an object's outline, it detects and tracks it using infrared light and optical sensors. These sensors have a 150° field of view and

their effective range extends from approximately 3 to 60 centimetres (Figure 16). Finally, to handle complicated tracking conditions, the Leap Motion software integrates sensor data with an internal model of the human hand [2].

4.2.2 The Hand Tracking Panda

Since the Leap Motion is a useful, compact device that does not obstruct the face tracking component, we believe that it is the ideal choice for this work. Therefore, in order to have the best performance in hand tracking, we chose to use the Leap Motion Controller in HMD mode because the Ultraleap Hand Tracking Plugin rotates the 3D hands to keep the correct orientation to the Unreal world when this mode is active [2]. In contrast with the Desktop Mounted Display (DMD) mode (Figure 18), we can see that hand orientation in DMD mode is not ideal for our work since we want to track gestures, which are primarily vertical and happen while individuals are communicating with one another. This concern could be resolved by rotating the data gathered by the Leap Motion Controller before it is applied in the hands of the metahuman, however doing so would cause the prototype to perform slightly slower. We also decided to position the Leap Motion on the chest using a shirt clip made by a 3D printer, as shown in Figure 20 (b) because using it on a VR support would obstruct the face tracking functionality (imagine having a VR headset as Figure 20 (a) and wanting the metahuman to blink its right eye).

Fig. 18: View of hands in DMD mode [2]

(a) Head (VR support) [83]

(b) Chest

Fig. 20: Head vs. Chest Mounted Mode

The official Ultraleap Tracking Plugin for Unreal Engine 4 utilizes pre-made blueprints to add hand tracking to a scene and play it in the editor. However, depending on the project, it may take a more customized approach using C++ or blueprints [84]. For our project, we attempted to adapt a custom rigging example map from the Ultraleap Plugin, which contained several animation blueprints [85], to create the new version of the Anonymous Panda prototype, beginning by seeing how each rigging was done and how we could adapt it to our metahumans' bones.

To use the rigging on our metahumans effectively, we had to re-parent the metahuman animation blueprint to "BodyStateAnimInstance". By utilizing the Body State system, we were able to map the tracked data collected by the Leap Motion Controller to the metahumans' skeletal mesh bones (Figure 21).

We used the two Mapped Bone Anim Data arrays that were previously seen (Figure 21), much like the two-handed example from the custom rigging map, and chose to disable the deformation mesh because the metahuman model does not yet allow deformation (Figure 22).

Since we disabled the deformation mesh, only the rotations were tracked. To move the elbows to their proper positions, we apply an animation node called Forward And Backward Reaching Inverse Kinematics (FABRIK) to each elbow. The FABRIK animation node is an Inverse Kinematics (IK) solver that handles joint rotation from the location of an end-effector rather than directly from the joint rotation. In practice, we designate an effector point, and the IK solution rotates the joint to be as close to that place as possible [86].

The majority of animated skeletons in UE are powered by direct rotational data fed into the character's bones or the Skeletal Mesh. This is known as Forward Kinematics (FK), or the direct application of rotation to joints or bones [86]. Figure 23 (a) illustrates a diagram of the concept.

Inverse Kinematics, on the other hand, works in the opposite way. Instead of rotating bones, we give the bone chain a target (also known as an end effector) that specifies where the chain's end should aim. The user moves the effector, and the IK solver (the algorithm that drives rotation in an IK system) rotates the bones until the last bone in the chain reaches the target location [86]. The end effector is shown by the red cross in Figure 23 (b).

Once again, in order to position the shoulders correctly, we had to rotate all of our mapped data by 90 degrees in the "Offset Transform" for Y, as is typical for skeletal meshes and as shown in Figure 22.

Concerning the prototype's outcome, Figure 24 depicts the steps taken from providing the IK with all of the data required for its operation to the metahuman's animation in the blueprint, after gathering data for the hands animation. Finally, Figure 25 and videos [87, 88] illustrate the outcome applied to one of the metahumans used in this study.

4.2.2.1 Challenges

The exploration of the Ultraleap Plugin was one of the first challenges encountered during the development of this version of the prototype. Despite being documented, the examples provided were difficult to replicate due to the limited amount of online content that could help with this issue. The problem was addressed by downgrading the plugin version to version 4.2.0.

After successfully recreating the plugin demonstrations, we decided to adapt the hand tracking via rigging into our animation blueprints Unfortunately, we were unable to replicate the rigging

(a) Left Side (b) Right Side

Fig. 21: Tracked data mapped to the metahumans' skeletal hands mesh bones

example. Our initial attempt is shown in Figure 26 (a), which only shows the left arm, and Figure 26 (b), which shows both arms. The shoulders and hands in both figures have a significant deformation, but they were still capable of movement.

We attempted several times to correct these deformations by following a YouTube tutorial [89], but we were unable to achieve the desired outcome. One of those attempts resulted in the arms being infinitely stretched, as demonstrated in Figure 27. Figure 28 depicts our latest attempt, and

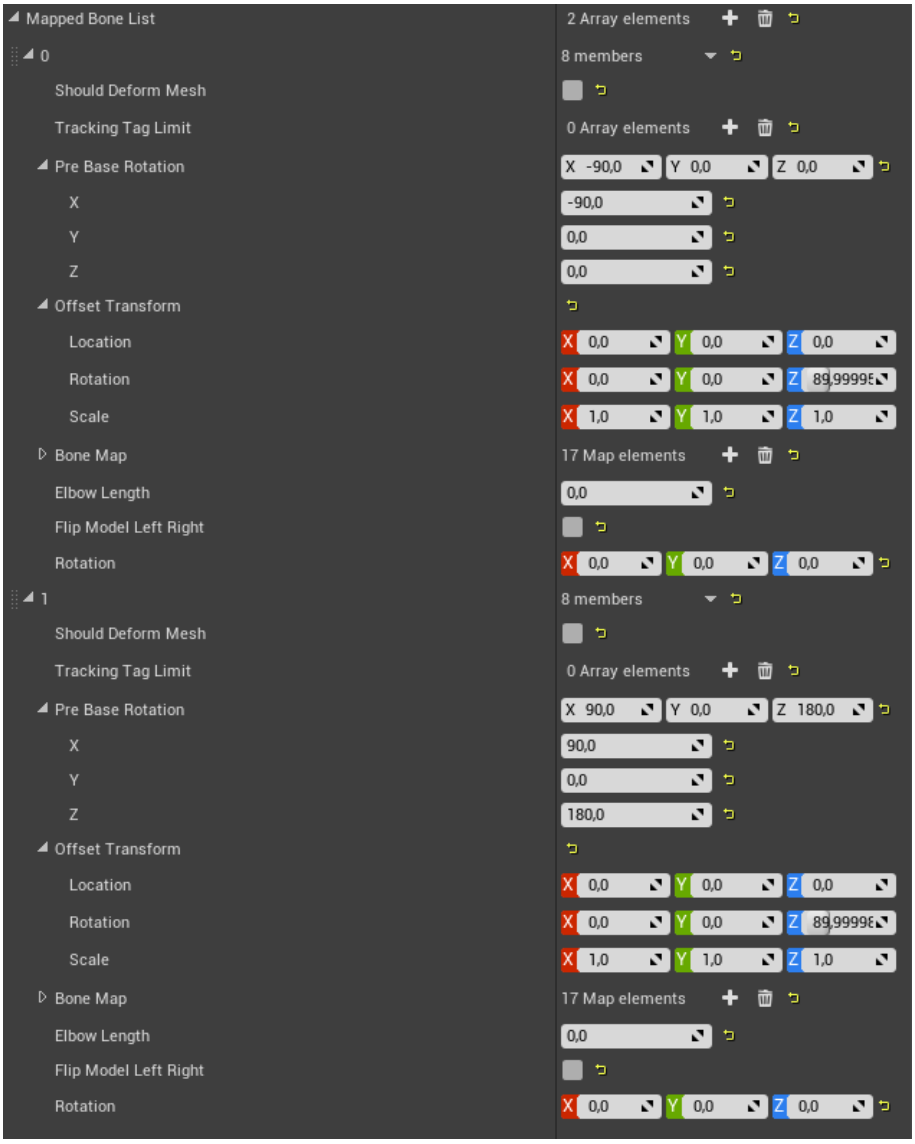


Fig. 22: Mapped Bone List

(a) Forward Kinematics [86]

(b) Inverse Kinematics [86]

Fig. 23: Diferences between FK and IK

we can see that the results are approaching our desired outcomes (Figure 25). However, in order to achieve a more realistic effect, we must elevate our metahumans' hands to waist level.

To offset the metahumans' hands and raise them to waist height, we added a positive constant on the Y-axis to the "Effector Transform Location" vector before the IK solver performed its magic.

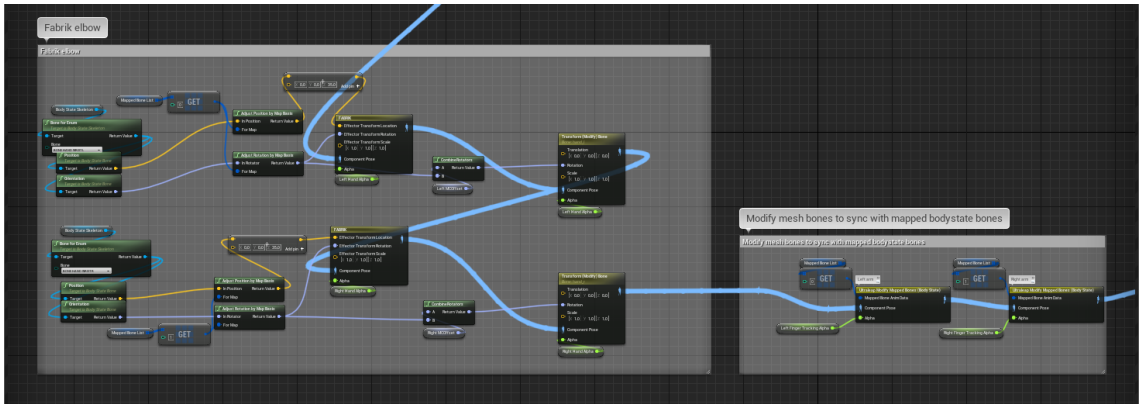


Fig. 24: Part of the blueprint in control of animating metahuman hands using data collected by leap motion

Fig. 25: The hand tracking's final outcome

Although the output was closer to what was intended, the fingers stopped functioning normally (Figure 29 and video [90]).

While trying to figure out how to get the fingers to work properly again,we avoided mapping the metacarpal bones of the fingers, which addressed our problem. However, the arms started to stretch out indefinitely once more (Figure 27). To solve this issue, we noticed that mapping the lower arm to none solved the problem, and thus we obtained our final result (Figure 25).

4.2.2.2 Limitations

Several studies [70, 73, 74] believe that hand gestures, along with facial expressions and spoken words, are essential in expressing our emotions. In order to achieve our goal of deeper emotional recognition, including hand tracking to the existing prototype was a crucial step. Because hands are the most crucial nonverbal clues for identifying particular states in others, after facial expressions and body position [73, 74].

(a) Hand and Shoulder deformation (b) Hands and Shoulders deformations

Fig. 26: Initial Hand Tracking Steps

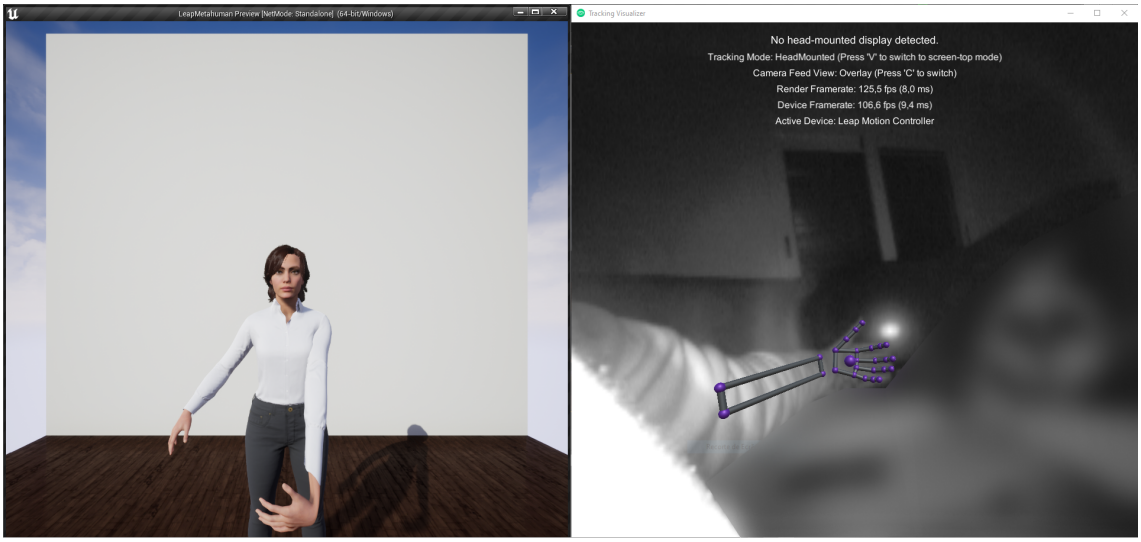


Fig. 27: Left arm stretching infinitely

There are a number of ways to accomplish hand tracking, such as with virtual reality equipment or gloves, but we felt that the Leap Motion Controller was the ideal choice for this work because it is a useful and compact device that does not interfere with the face recognition component. This device, however, has significant limitations. There is a reliance on the usage of the USB cable for leap motion and unreal communication, and because it is an old device, acquiring it may be difficult. Additionally, infrared sensors may not function properly in bright environments, and

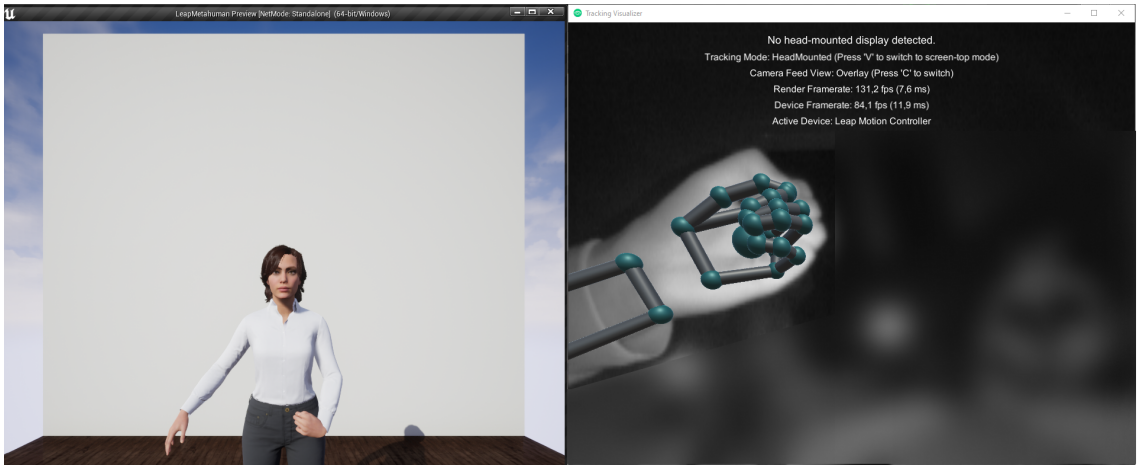


Fig. 28: One step closer to the final outcome

Fig. 29: Issues with the fingers as the outcome neared

turning on the HMD mode requires the Ultraleap Visualizer program rather than the blueprint configuration because doing so interferes with the hand tracking data.

Last but not least, a 3D-printed dependency of two shirt clips is shown in Figure 20 (b). In the beginning, only one shirt clip was required, however throughout the prototype tests, instability and imprecise hand tracking capture were detected. Although the two clips are currently functional, a more stable and user-friendly solution would be preferable.

4.3 Methodology

The purpose of this study is to put to the test a modified version of the Technology Acceptance Model (TAM) created to study users' acceptance of our work, the Anonymous Panda. Furthermore,

we want to assess if virtual avatars can help promote interactants' verbal self-disclosure or not ($\mathbf{RQ_2}$).

The TAM estimates user intention to utilize a particular technology based on two user perceptions: perceived utility and perceived ease of use. Perceived usefulness is defined as "the amount to which a person believes that using a certain system will improve his or her job performance" [91]. In contrast, perceived ease of use is defined as "the degree to which a person believes that using a certain technology would be devoid of effort" [91].

The Technology Acceptance Model is a practical model that can be applied in a lot of situations, and it has been refined via several research to accommodate various technologies, situations, and users. TAM adaptations have been proposed for features from similar models (e.g., subjective norm, perceived behavioral control), new belief factors (e.g., triability, content richness), and external variables (e.g., demographic characteristics, computer self-efficacy) [92]. External variables can act as predictors or moderators of perceived usefulness and usability. By including new variables, these extensions try to improve the TAM's capacity to predict outcomes for specific technologies, situations, and users [92].

Several investigations using the TAM to analyze a person's intention to utilize specific technologies have shown that the TAM can be beneficial in a broad range of situations [92]. Furthermore, they discovered that perceived utility and perceived simplicity of use predicted use intention. And finally, discovered a significant relationship between perceived ease of use and perceived usefulness. However, to the best of our knowledge, little research has been conducted on the relationship between Perceived Anonymity (PA) and Online Public Disclosure (OPD), two important variables for our research.

To assess the feasibility of the previously described approach and test users' acceptance of our application, as well as users' OPD, we conducted a controlled prototype testing in order to assess if the Anonymous Panda had an effect on participants' perceived anonymity (PA), online public disclosure (OPD), perceived usefulness (PU), and perceived ease of use (PEU), which can help us demonstrate users' acceptance.

4.3.1 Participants

Participants were required to be at least 18 years old and a member of the Interactive Technologies Institute. They were personally invited to partake in the research and were given a general overview of the study's topic. Our final sample consists of 20 individuals (11 males, 9 females), aged between 18 and 46 (M=28.75, SD=6).

Those who agreed to participate (N=20) were first given an informed consent form. Participants were asked to fill out basic demographic questions as well as a self-assessment questionnaire to determine their baseline levels of online public disclosure for this experiment. They were then taken to a room for at least 2 minutes to test our prototype before being asked some follow-up questions.

4.3.2 Procedure

To recruit participants, we personally announced the start of our study to the entire Interactive Technologies Institute population. Those who were interested in our work and agreed to participate

in the study (N=20) were first given an informed consent form (see Appendix E) and were fully informed about the study's broad and general topic.

Participants were asked to fill out basic demographic questions (see Appendix E) as well as some questions about their OPD, as proposed by [93]. They were then led to a room with a setup (see Figure 30) where they could test our prototype for a short period of time (see Figure 31). Participants were not assigned any specific tasks; instead, they were simply asked to interact with the prototype and test the different tracking sensors.

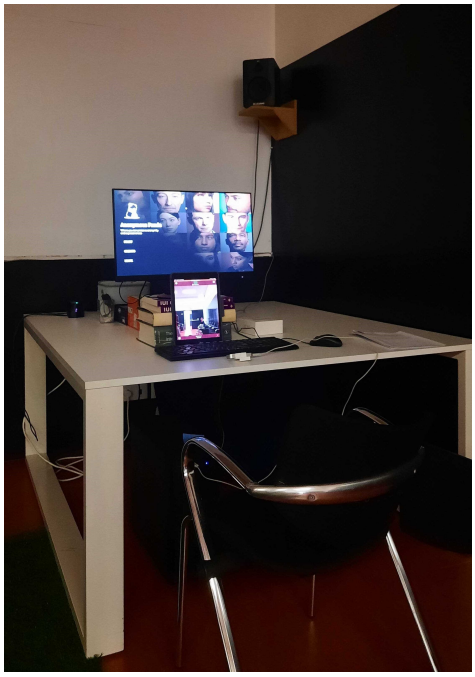


Fig. 30: Room Setup

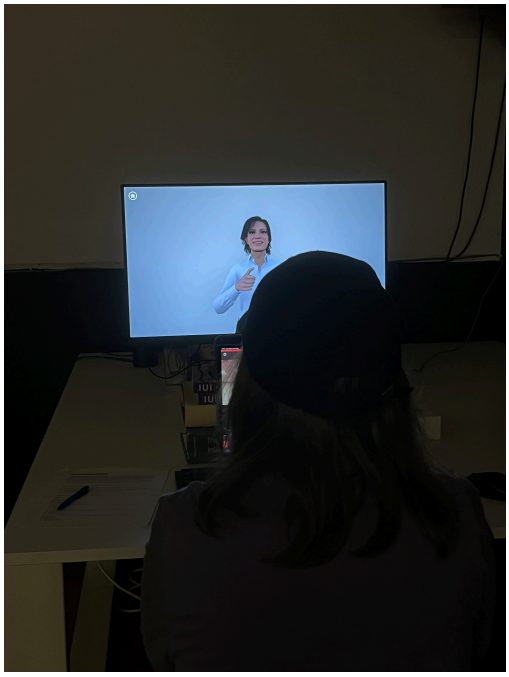


Fig. 31: Participant testing our prototype

The participants were then asked to complete a questionnaire designed to assess their perceived anonymity, online public disclosure, perceived usefulness, and perceived ease of use in response to their interaction with our prototype, as proposed by [93, 94].

For the pre questionnaire (see Appendix F) we used five questions to assess the participants' online public disclosure on a seven-point Likert-type scale (1=totally disagree, 7=totally agree), based on the work of Haejin Yun [93]. The five items used to test OPD were: "Usually, I am willing to share my family history and/or secrets", "Usually, I am willing to talk about my failures", "Usually, I am willing to express my most intimate feelings", "Usually, I am willing to talk about my shameful experiences", and "Usually, I am willing to share things I wouldn't normally share with my family, friends and colleagues".

Regarding the post-questionnaire (see Appendix G), twenty questions divided into four categories were used, on a seven-point Likert-type scale (1=totally disagree, 7=totally agree), based on the works of Haejin Yun [93] and Hite et al. [94]. Through five questions, each category is responsible for evaluating the participants' perceived anonymity, online public disclosure, perceived usefulness, and perceived ease of use in response to their interaction with our prototype.

Based on the work of Hite et al. [94], the five questions used to assess the participants' PA were as follows: "While using Anonymous Panda, I am confident others will not know who I am", "While using Anonymous Panda, I think someone may recognize me from my voice", "While using Anonymous Panda, I think someone may recognize me from expressions or words I use frequently", "While using Anonymous Panda, I think someone may find out how old I am", and "While using Anonymous Panda, I am afraid someone will find out who I am".

The questions used to assess the participants' OPD were similar to those used in the pre questionnaire, but with one minor difference. It asked how the participant felt while using the Anonymous Panda rather than how they normally felt. In other words, we used the pre and post questionnaire questions to see if there was a significant difference in participants' online public disclosure before and after our prototype testing.

The following five items were used to assess the participants' PU: "Using Anonymous Panda would make it easier to express my feelings", "Using Anonymous Panda would increase my willingness to ask for mental health support", "Using Anonymous Panda would enable me to have a more stable mental health quickly", "I think Anonymous Panda can be useful for mental health therapy", and "I feel I am more willing to talk about my problems". PEU was then tested using the following items: "My interaction with Anonymous Panda was clear and understandable", "It was easy to get Anonymous Panda to do what I wanted it to do", "Learning how to use Anonymous Panda was easy for me", "Using Anonymous Panda is intuitive", and "I think Anonymous Panda is easy to use".

Finally, in an open-ended question, participants could express their thoughts on our prototype, as well as what they disliked or thought could be improved. They could also share with us if they used a similar application to ours.

4.3.3 Hypotheses and Statistical Analyses

The goal of this study is to put to the test an extended TAM designed to study the users' acceptance of the Anonymous Panda, and determine whether virtual avatars can promote interactants' verbal self-disclosure or not ($\mathbf{RQ_2}$). Therefore, we propose the three following hypotheses:

$\boldsymbol{H_1}$ - PA has a positive effect on OPD.

$\boldsymbol{H_2}$ - PA has a positive effect on PU.

$\boldsymbol{H_3}$ - PU has a positive effect on OPD.

To test $\boldsymbol{H_1}$-$\boldsymbol{H_3}$, we used the Spearman's Rank correlation to determine if there was a statistically significant correlation between the four variables: PA, OPD, PU, and PEU.

We also wanted to assess if the participants' willingness to provide personal information online altered considerably before and after using the Anonymous Panda application. Due to the fact that participants were measured more than once for the dependent variable, a repeated measures analysis method was required. Therefore, we conducted a Wilcoxon signed-rank test to evaluate whether the participants' willingness to disclose personal information online had changed compared to before they used the Anonymous Panda application. Cronbach's Alpha was also used to ensure the reliability of our questionnaire. Finally, using a statistical significance level of 0.05, all of this data was evaluated in the IBM SPSS statistics software (v.28, 2021).

4.3.4 Results

Tables 3, 4, 5, and 6 describes the different items that have been asked regarding the users' acceptance of our application. The PA part consisted of 5 items (α=.65), the OPD part consisted of 5 items (α=.84), the PU part consisted of 5 items (α=.89), and the PEU part consisted of 5 items (α=.80).

	Mean	Std. Deviation
I am confident others will not know who I am	6.30	1.081
I think someone may recognize me from my voice	3.35	1.565
I think someone may recognize me from expressions or words I use frequently	4.40	1.501
I think someone may find out how old I am	5.30	2.003
I am afraid someone will find out who I am	5.45	1.276

Cronbach's Alpha	N of Items
.647	5

Table 3: Perceived Anonymity items results

	Mean	Std. Deviation
I am willing to share my family history and/or secrets	4.35	1.663
I am willing to talk about my failures	5.20	1.704
I am willing to express my most intimate feelings	4.40	1.818
I am willing to talk about my shameful experiences	4.85	1.424
I am willing to share things I wouldn't normally share with my family, friends and colleagues	4.35	1.694

Cronbach's Alpha	N of Items
.844	5

Table 4: Online Public Disclosure items results

	Mean	Std. Deviation
I feel I am more willing to talk about my problems	5.45	1.234
I think Anonymous Panda can be useful for mental health therapy	6.15	.988
Using Anonymous Panda would enable me to have a more stable mental health quickly	4.45	1.572
Using Anonymous Panda would increase my willingness to ask for mental health support	5.25	1.552
Using Anonymous Panda would make it easier to express my feelings	4.95	1.504

Cronbach's Alpha	N of Items
.894	5

Table 5: Perceived Usefulness items results

To evaluate correlation between the PA, OPD, PU, and PEU, we conducted a Spearman's Rank Correlation test. The test revealed no significant relationship between the participants' Perceived Anonymity and Online Public Disclosure (r_s=.29, p=.22, N=20). However, the test revealed several significant correlations between the participants' Perceived Anonymity and Perceived Usefulness

	Mean	Std. Deviation
I think Anonymous Panda is easy to use	6.10	.968
Using Anonymous Panda is intuitive	6.05	.887
Learning how to use Anonymous Panda was easy for me	6.50	.688
It was easy to get Anonymous Panda to do what I wanted it to do	5.70	1.174
My interaction with Anonymous Panda was clear and understandable	5.95	.945

Cronbach's Alpha	N of Items
.804	5

Table 6: Perceived Ease of Use items results

(r_s=.46, p=.04, N=20), Perceived Anonymity and Perceived Ease of Use (r_s=.52, p=.02, N=20), Perceived Usefulness and Online Public Disclosure (r_s=.57, p=.01, N=20), Perceived Usefulness and Perceived Ease of Use (r_s=.64, p=.00, N=20), and finally, Perceived Ease of Use and Online Public Disclosure (r_s=.46, p=.04, N=20). Table 7 shows the significant correlations between the variables (Appendix H shows the correlations between each question), whereas Figure 32 shows the various correlations obtained from the Spearman's Rank Correlation test.

		PA	PU	OPD	PEU
PA	Correlation Coefficient	1.000	.456*	.288	.515*
	Sig. (2-tailed)	.	.043	.219	.020
	N	20	20	20	20
PU	Correlation Coefficient	.456*	1.000	.566**	.640**
	Sig. (2-tailed)	.043	.	.009	.002
	N	20	20	20	20
OPD	Correlation Coefficient	.288	.566**	1.000	.457*
	Sig. (2-tailed)	.219	.009	.	.043
	N	20	20	20	20
PEU	Correlation Coefficient	.515*	.640**	.457*	1.000
	Sig. (2-tailed)	.020	.002	.043	.
	N	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlations between our variables

These findings suggest that there are no statistically significant correlation that could support our $\boldsymbol{H_1}$, namely that participants' perceived anonymity influences users' willingness to disclose personal information online. However, these results support our $\boldsymbol{H_2}$ and $\boldsymbol{H_3}$, which state that participants' perceived anonymity effects their perceived usefulness and that participants' perceived usefulness increases users' willingness to disclose personal information online.

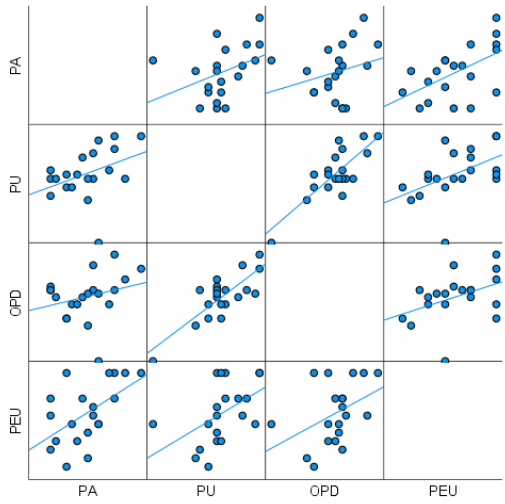


Fig. 32: Scatter Plot Matrices

Finally, to assess the difference in the participants' willingness to provide personal information online after using the Anonymous Panda app, a Wilcoxon signed-rank test was performed. The results demonstrated a statistically significant improvement in the users' willingness to disclose personal information online following the use of the application (Z=-2.543, p=.011), with a large effect size (r=.57).

4.3.5 Discussion

In this study, we utilized a modified version of Technology Acceptance Model developed to analyze the acceptance of our work among several users. Additionally, we hoped to see whether or not virtual avatars could improve users' verbal self-disclosure ($\mathbf{RQ_2}$).

Regarding our $\boldsymbol{H_1}$, we did not a find significant relationship between the users' perceived anonymity and online public disclosure. That is, the fact that others are unaware of the participant's identity has little or no effect on their desire to disclose personal information online. However, after utilizing the Anonymous Panda, participants' willingness to share personal information online improved, but it appears that it did not relieve their concern of their identity being revealed. This could be due to external factors or factors not included in our questionnaire, but it could also be due to the use of a self-reported questionnaire, as there is a possibility that individuals provided inaccurate answers [65].

Concerning our $\boldsymbol{H_2}$, we discovered a significant connection between users' perceived anonymity and perceived usefulness. In other words, the participants' perception of the Anonymous Panda application seems to improve due to the fact that others are unaware of their identities. That is, if the users' PA effects their PU, as indicated by our findings, and PU promotes the users' intention to use a given app, as demonstrated by [91], we may assume that PA also influences the users' desire to use our app. Furthermore, we also we discovered a favorable correlation between the user's perceived usefulness and perceived ease of use, which is in agreement with the current literature on the TAM model [91].

Similarly, we found a significant correlation between users' perceived usefulness and online public disclosure ($\boldsymbol{H_3}$). This suggests that users are more likely to increase their ability to pro-

vide personal information online if they find the Anonymous Panda application useful. Other research [95, 96] also has shown that perceived usefulness influences people's disclosure of personal information.

Finally, we evaluate the difference of online public disclosure before and after using the anonymous panda app in order to validate our $\mathbf{RQ_2}$ that virtual avatars could improve users' verbal self-disclosure. Our findings showed a statistically significant positive change in participants' willingness to disclose personal information online after using the anonymous panda app. However, these results could be easily distorted since we used a self-reported questionnaire, therefore there's a chance that individuals gave invalid answers [65], and because our $\boldsymbol{H_1}$ was rejected, these results may not be related to the virtual avatars themselves.

4.4 Anonymous Panda User Interface

Most of the feedback collected during the prototype's demonstrations was related to the interface. The majority of this feedback was connected to the lack of other metahumans, which were present but the opportunity to switch between them was not easily identified, and users were always forced to choose between the initial two metahumans since they were unaware of this option. In response to these critiques, we made an effort to develop a new user interface that was simpler to use and made all of the prototype's metahumans available at the time of user selection (Figure 33). Since the prior study did not allow us to test the user interface with actual users, we were unable to identify this issue which could have been addressed earlier.

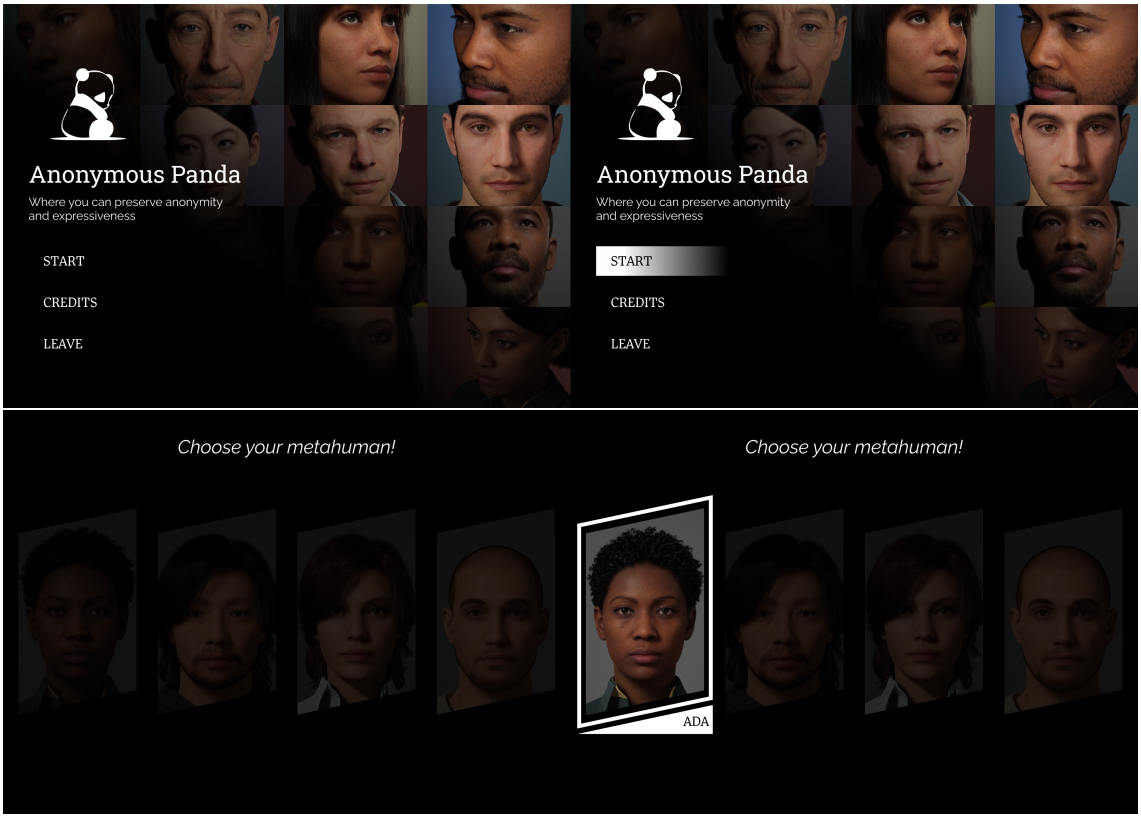


Fig. 33: New Anonymous Panda UI

4.5 Anonymous Panda Resources and Workflow

Because this work is far from complete and has a very important and useful theme, all development is open-source and available on GitLab at the following url: `https://gitlab.com/inarie/anonymous-panda`.

To replicate the studies, an iPhone with a model equal to or greater than the XS is required for facial tracking and a leap motion for hand tracking as seen in Figure 34. The Live Link app must be installed on the iPhone, and the IP address of the computer running Anonymous Panda must be configured in this app so that all necessary data is communicated. For hand tracking, simply connect the Leap Motion via USB and place it in a support around the chest area, then install the UltraLeap Control Panel and keep it open while the computer was running Anonymous Panda.

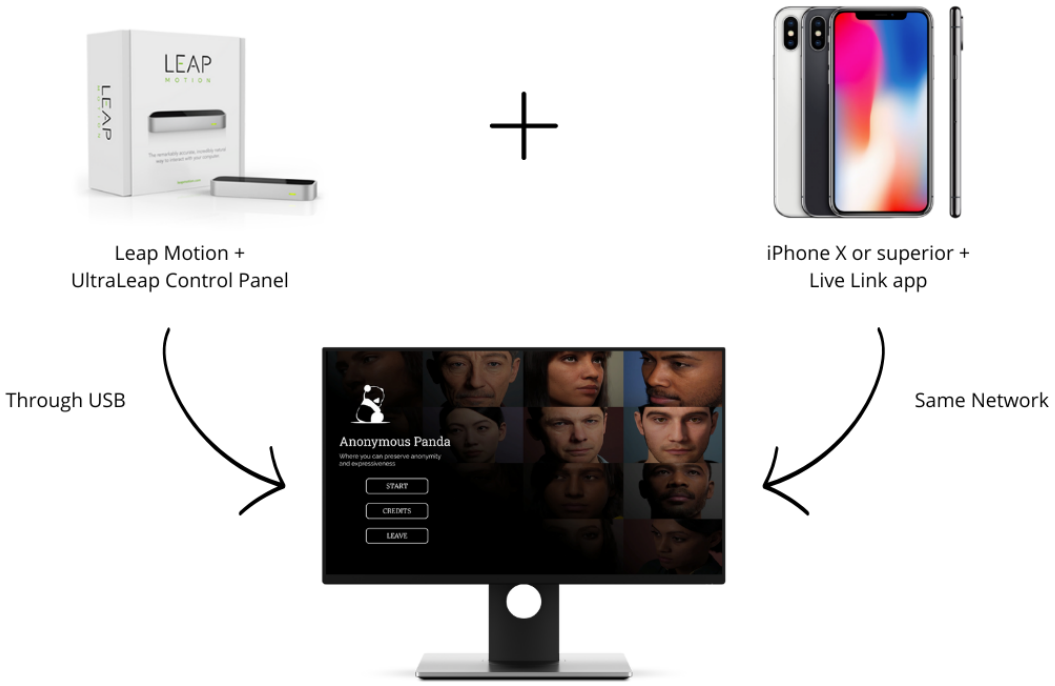


Fig. 34: Necessary Software and Hardware

5 Conclusion and Future Work

In the pursuit of human happiness and well-being, it is critical to assist individuals in being more honest. This goal has aided in the development of a new type of assistive technology capable of anonymously linking people with mental health specialists in order to overcome the limitations of anonymity and security in videoconferencing therapy, as well as the lack of expressiveness in text/phone therapy.

One of the main contributions of our work involves the use and development of new capabilities with ultra-realistic virtual human avatars known as Metahumans. Despite the fact that other researchers have addressed problems similar to ours [27–34], our work is essential because the VA used in this experiment are new and unexplored. Furthermore, they demonstrate more realistic human features than other works, meaning that similar works' findings cannot be considered relevant because the conditions are different.

Our primary study assessed users' empathy with metahumans in order to determine whether these virtual avatars were able to convey the same emotional depth as a real person ($\mathbf{RQ_1}$). To find out if our stimulus had an impact, we conducted a between-subjects experiment with 48 participants to measure their CE and AE. The findings of this study were a first step toward a better understanding of the potential use of ultra-realistic virtual human avatars in videoconference therapy. They also revealed that the virtual avatar's lack of hand movement constrained their capacity to express themselves, giving the impression that they were acting like puppets or in an unnatural way. This particular result led us to wonder whether or not the addition of hand tracking would aid improve interactants' verbal self-disclosure ($\mathbf{RQ_2}$).

According to many studies [70, 73, 74], hand gestures, together with facial expressions and spoken words, play a significant part in transmitting our emotions. As a result, incorporating hand tracking into our prototype is a critical step toward our aim of deeper emotional detection. Because, aside from facial expressions and body posture, the most crucial nonverbal clues for distinguishing specific states in others are hands [73, 74].

Through controlled prototype testing, as well as a questionnaire, our second study investigated the viability of our work and tested users' acceptance of the application as well as users' OPD. Despite the fact that not all of our hypotheses were accepted, through the study's findings, we were able to acknowledge the potential of our work and analyze what could be lacking and improved to make our work truly useful and easy to use. Furthermore, we attempted to determine whether virtual avatars may improve users' verbal self-disclosure ($\mathbf{RQ_2}$), but we were unable to confirm it since we could not establish a relationship between the users' perceived anonymity and online public disclosure.

Overall, our research improved our comprehension of the prospective use of ultra-realistic virtual human avatars in videoconferencing therapy, i.e., both studies helped us understand how vital facial and body expressions are and how problematic their absence is in communicating with others [75]. It was, however, impossible to discover a relation between users' perceived anonymity and online public disclosure. This correlation was fundamental for our work since it allowed us to determine whether the role of virtual avatars was beneficial to users.

Despite our findings being relatively good, plenty of improvements that could be done in order to achieve better results were postponed due to time constraints. In the following sections, we provide some of the outstanding parts of this work that deserve additional development and investigation:

5.1 Custom Metahuman Parameters

One of the most important things for the anonymous face tracking panda application to work is obtaining a facial mesh, which is a 3D representation of a face that allows us to provide data to express ourselves through the metahuman's face.

Although the current prototype performs the most of the captured facial expressions, a minor issue with the metahumans' lip position was discovered during the second experiment. As a result, since each user has a unique facial mesh that is never exactly the same as someone else's, the modification performed in Chapter III (Figure 6) does not permit covering all application users.

This issue could be resolved by including a calibration option that would enable the definition of a constant that would address the issue of lip position in the metahuman in accordance with each individual's lip position.

5.2 Custom Metahuman Upload

In addition to the four existing metahumans (Figure 4), it would be intriguing to add the ability to import customized metahumans. This additional feature would allow users to engage with the anomynous panda application more effectively, potentially making them feel more at ease with their new physical appearance. Furthermore, this could boost people's willingness to expose their circumstances and be themselves without fear of being criticized by others.

5.3 In-app Videoconference

Because our primary goal is to connect mental therapists with patients, videoconferencing is a vital step in this initiative. Although our work can already be used as a virtual camera, it is critical to make this feature more practical and independent of other external programs (see Figures 7 and 8), such as OBS Studio, because not all users have medium/advanced computer skills to understand what is required. One solution could be to make our work available remotely using [3] (similar to Figure 35), with only the patient providing inputs to the metahuman such as face and hand tracking information and both patient and therapist on an embedded videoconference.

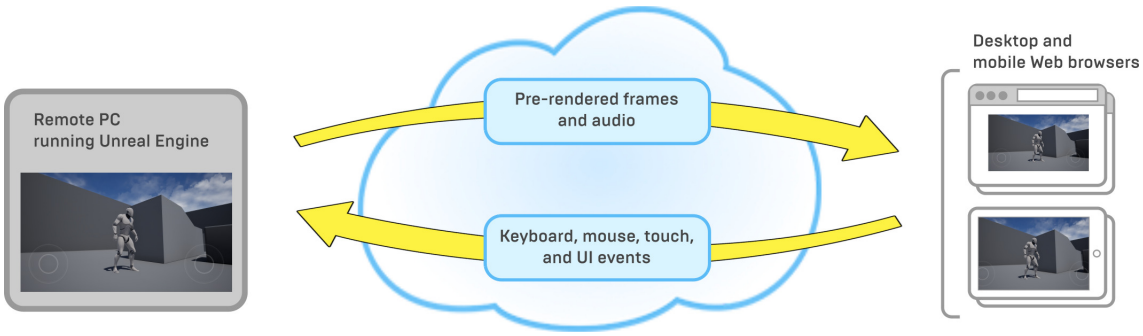


Fig. 35: UE application working remotely [3]

5.4 Voice Anonymization

The user's voice being made anonymous is another crucial feature to include. This feature, in addition to increasing anonymity, will allow the user to feel more at ease during their online session of mental therapy, increasing willingness to expose their circumstances and be themselves without fear of others recognizing their voice. However, a simple pitch change is insufficient to mask a voice, as an entity could simply pitch the audio back to recover the original audio. This means that additional research may be required in order to find a solution.

5.5 Correlation between PA and OPD

As previously said, additional research into the relationship between users' perceived anonymity and online public disclosure is important since it may indicate how our metahumans play the role of anonymity when used in videoconferencing. The addition of customized metahumans, as well as the integration of voice anonymization, could improve this relationship, but everything inevitably depends on the user and how they perceive the potential and value of our work.

5.6 Influence on Mental Health Therapy

Finally, a new study could help understand Anonymous Panda's influence in mental health therapies. It would also be interesting to learn what it would be like for a therapist to read facial/body expressions and feelings through our metahumans, and whether they would be able to identify all of the information needed during a mental health therapy, among other things, and then use those results to improve our work.

5.7 The Dark Side of Anonymity

Although anonymity can be used to protect people's privacy in cases such as mental health therapy, interviews and/or testimonials, being anonymous online is not always related to positive things. Developers of systems that provide this level of anonymity must be aware that their systems can be used for slander, illegal threats, racial agitation, or other polarizing topics. Some people, for example, use these systems to make derogatory remarks about others, which is commonly known as cyberbullying [97]. Because of the extensive harm it can cause the victim, cyberbullying is a serious cultural issue. In fact, studies have shown that those who become victims of cyberbullying are more likely to experience adverse behavioural (such as drug abuse [98] and poor academic performance [99]) as well as psychological (such as fear [100], depression [101], and suicidal ideation [102]) outcomes.

While we acknowledge the negative impact that online anonymity can have on society, this work focuses on the development and implementation of the anonymous panda application, as well as on the people who could benefit from such systems (as discussed in greater detail in the following section). Even though the ethical and moral implications related to these type of applications are beyond the scope of this thesis, it is worth noting that future work should investigate the implications of such systems for the general public, as well as the potential negative consequences they can bring to society.

5.8 Prospective Uses

Despite the fact that our findings are relatively good, we were unable to conduct any testing with healthcare professionals due to time constraints. With this limitation, determining whether the anonymous panda could positively influence mental health therapies is challenging.

Nonetheless, we believe that contexts other than mental health therapy could benefit from additional privacy protection systems such as those developed by Anonymous Panda. One practical example could be to anonymize witnesses in high-profile cases where depending on what they are testifying about, they may be victims of some kind of retaliation for revealing their true identity. Furthermore, they can be used in business settings to train employees in emotional and social soft skills, as the anonymous panda can create a more relaxed environment.

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Appendix

A Story - AITA for telling my roommate her sister has to pay rent?

So I got an apartment with my best friend 1.5 years ago and it has been a rocky relationship ever since. We literally go weeks without talking. Last year she let a friend crash on the couch for months and he only split the bills one time in like six months. I later found out that he was actually just splitting her half of the bills with her. I later found out he was in fact paying bills but he was splitting her half of the bills. Our rent is $600 a month and instead of all of us paying $200. i paid $300 and they each paid $150. I felt that was unfair seeing how he was sleeping in the living room and I could no longer access it and it inconvenienced me but it didn't matter anymore because I didn't find out until after he moved out. Now she has told me her sister will be moving in due to family issues and I told her head on we should split the bills 3 ways since she's sleeping in the living room & not sharing the room with my roommate. She feels that her sister should only split her half with her since she's "her responsibility & company." AITA for telling her that her sister has to split the bills evenly or she can't stay in the living room? [This is the original Reddit story. The story is told in Portuguese on the videos.]

B Pre Questionnaire - Study 1

Normalmente *

	Discordo totalmente	Discordo um pouco	Não concordo nem discordo	Concordo um pouco	Concordo totalmente
Quando outra pessoa se sente entusiasmada, eu também tenho tendência a ficar entusiasmado	○	○	○	○	○
As infelicidades das outras pessoas não me perturbam muito	○	○	○	○	○
Chateia-me ver alguém a ser tratado com desrespeito	○	○	○	○	○
Não me sinto afectado quando alguém próximo de mim é feliz	○	○	○	○	○
Gosto de fazer as outras pessoas sentirem-se melhor	○	○	○	○	○
Tenho sentimentos de ternura e preocupação pelas pessoas menos favorecidas do que eu	○	○	○	○	○
Quando um amigo começa a falar sobre os seus problemas, eu tento desviar a conversa para outra coisa	○	○	○	○	○
Posso dizer quando os outros estão tristes, mesmo quando não dizem nada	○	○	○	○	○
Vejo-me como uma pessoa que tem uma personalidade assertiva	○	○	○	○	○
Vejo-me como uma pessoa que é útil e altruísta com os outros	○	○	○	○	○
Vejo-me como uma pessoa que é persistente até ao fim de uma tarefa	○	○	○	○	○
Vejo-me como uma pessoa que se preocupa muito	○	○	○	○	○
Vejo-me como uma pessoa que é curiosa sobre muitas coisas diferentes	○	○	○	○	○
Acho que estou "em sintonia" com o estado de espírito dos outros	○	○	○	○	○
Não sinto simpatia por pessoas que causam as suas próprias doenças graves	○	○	○	○	○
Fico irritado quando alguém chora	○	○	○	○	○
Não me interesso realmente por como as outras pessoas se sentem	○	○	○	○	○
Fico com uma forte vontade de ajudar quando vejo alguém que está chateado	○	○	○	○	○
Quando vejo alguém a ser tratado injustamente, não sinto muita pena por ele	○	○	○	○	○
Acho uma parvoíce as pessoas gritarem de felicidade	○	○	○	○	○
Quando vejo alguém a que estão a aproveitar-se, sinto-me um pouco protector em relação a essa pessoa	○	○	○	○	○

C Post Questionnaire - Study 1 - Pre-recorded videos

Ao ver o vídeo *

	Discordo totalmente	Discordo	Discordo um pouco	Não concordo nem discordo	Concordo um pouco	Concordo	Concordo totalmente
Sinto que a pessoa está a observar-me e está consciente da minha presença	○	○	○	○	○	○	○
A ideia de que a pessoa não é uma pessoa real passa-me frequentemente pela cabeça	○	○	○	○	○	○	○
A pessoa parece estar consciente e viva para mim	○	○	○	○	○	○	○
Considero a pessoa como sendo apenas uma imagem computadorizada, não como uma pessoa real	○	○	○	○	○	○	○
Compreendo o que a levou a ficar chateada	○	○	○	○	○	○	○
As suas reações à situação são compreensíveis	○	○	○	○	○	○	○
Compreendo porque é que ela se sente excluída	○	○	○	○	○	○	○
Consigo relacionar-me com o seu problema	○	○	○	○	○	○	○
Quando vejo alguém numa situação injusta, sinto-me frustrado(a)	○	○	○	○	○	○	○
Sinto que as suas emoções são genuínas	○	○	○	○	○	○	○

D Post Questionnaire - Study 1 - Transcript

Ao ler o relato pessoal *

	Discordo totalmente	Discordo	Discordo um pouco	Não concordo nem discordo	Concordo um pouco	Concordo	Concordo totalmente
Compreendo o que a levou a ficar chateada	○	○	○	○	○	○	○
As suas reações à situação são compreensíveis	○	○	○	○	○	○	○
Compreendo porque é que ela se sente excluída	○	○	○	○	○	○	○
Consigo relacionar-me com o seu problema	○	○	○	○	○	○	○
Quando vejo alguém numa situação injusta, sinto-me frustrado(a)	○	○	○	○	○	○	○
Sinto que as suas emoções são genuínas	○	○	○	○	○	○	○

E Consent Form and Demographic Questions - Study 2

Anonymous Panda

Este questionário faz parte de uma investigação em curso, na sequência de uma Tese de Mestrado em Engenharia Informática, que visa compreender o anonimato e a expressividade em consultas de psicologia on-line. O preenchimento deste questionário levará menos de 15 minutos, e todas as suas respostas permanecerão confidenciais. Se tiver alguma dúvida sobre este estudo, não hesite em contactar Érica Freitas (investigadora principal) ou Professor Pedro Campos (orientador).
This questionnaire is part of an ongoing investigation which aims to understand anonymity and expressiveness in online therapy for mental health. Completing this questionnaire will take less than 15 minutes, and all your responses will remain confidential. If you have any questions about this study, do not hesitate to contact Érica Freitas (main researcher) or Professor Pedro Campos (supervisor).

Por favor, confirme o seu consentimento para os seguintes procedimentos: Please confirm you consent to the following:

- ◯ Autorizo a utilização dos meus dados anonimizados no estudo actual I authorize the use of my anonymized data in the current study
- ◯ Concordo que os meus dados anonimizados sejam partilhados com investigadores que ainda não sejam conhecidos I agree to my anonymized data being shared with researchers not yet known
- ◯ Concordo em participar no estudo I agree to participate in this study

---

Informação Demográfica Demographic Information

Idade Age _____

Género Gender
- ◯ Masculino Male
- ◯ Feminino Female
- ◯ Outro Other _____
- ◯ Prefiro não dizer I'd rather not say

Já consultou algum psicólogo e/ou psiquiatra? Have you ever been to therapy and/or a psychiatrist?
- ◯ Sim Yes
- ◯ Não No
- ◯ Prefiro não dizer I'd rather not say

Se sim, já teve alguma consulta online (por exemplo, durante a pandemia)? If yes, have you had any online session (during the pandemic, for example)?
- ◯ Sim Yes
- ◯ Não No
- ◯ Prefiro não dizer I'd rather not say

Como classifica o seu nível de conhecimento no domínio da informática? How would you rate your computer skills?
- ◯ Básico Basic
- ◯ Mediano Median
- ◯ Avançado Advanced

F Pre Questionnaire - Study 2

Leia cada uma das seguintes frases e escolha como se sente normalmente. Não há respostas erradas.
Read each of the following sentences and choose how you usually feel. There are no wrong answers.

Normalmente… **Usually…**

	Discordo totalmente Totally disagree						Concordo totalmente Totally agree
	1	2	3	4	5	6	7
Estou disposto a compartilhar minha história familiar e/ou segredos I am willing to share my family history and/or secrets	○	○	○	○	○	○	○
Estou disposto a falar sobre os meus fracassos I am willing to talk about my failures	○	○	○	○	○	○	○
Estou disposto a expressar os meus sentimentos mais íntimos I am willing to express my most intimate feelings	○	○	○	○	○	○	○
Estou disposto a falar sobre assuntos que me possam envergonhar I am willing to talk about my shameful experiences	○	○	○	○	○	○	○
Estou disposto a compartilhar coisas que não faria pessoalmente com a minha família, amigos e colegas de trabalho I am willing to share things I wouldn't normally share with my family, friends and colleagues	○	○	○	○	○	○	○

G Post Questionnaire - Study 2

Abaixo encontram-se uma série de frases que descrevem sentimentos em relação à utilização do *Anonymous Panda*. Leia cada uma delas e escolha como se sente neste momento. Não há respostas erradas. Below you will find sentences that describe feelings about using *Anonymous Panda*. Read each one and choose how you feel right now. There are no wrong answers.

Ao utilizar o Anonymous Panda… While using Anonymous Panda…

	Discordo totalmente Totally disagree						Concordo totalmente Totally agree
	1	2	3	4	5	6	7
Estou confiante de que os outros não saberão quem eu sou I am confident others will not know who I am	○	○	○	○	○	○	○
Acho que alguém pode me reconhecer pela minha voz I think someone may recognize me from my voice	○	○	○	○	○	○	○
Sinto que posso falar sobre os meus problems mais facilmente I feel I am more willing to talk about my problems	○	○	○	○	○	○	○
Acho que alguém pode me reconhecer por expressões ou palavras que uso com frequência I think someone may recognize me from expressions or words I use frequently	○	○	○	○	○	○	○
Acho que alguém pode descobrir a minha idade I think someone may find out how old I am	○	○	○	○	○	○	○
Estou disposto a compartilhar minha história familiar e/ou segredos I am willing to share my family history and/or secrets	○	○	○	○	○	○	○
Estou disposto a falar sobre os meus fracassos I am willing to talk about my failures	○	○	○	○	○	○	○
Estou disposto a expressar os meus sentimentos mais íntimos I am willing to express my most intimate feelings	○	○	○	○	○	○	○
Estou disposto a falar sobre assuntos que me possam envergonhar I am willing to talk about my shameful experiences	○	○	○	○	○	○	○
Tenho receio que alguém possa descobrir quem sou I am afraid someone will find out who I am	○	○	○	○	○	○	○
Estou disposto a compartilhar coisas que não faria pessoalmente com a minha família, amigos e colegas de trabalho I am willing to share things I wouldn't normally share with my family, friends and colleagues	○	○	○	○	○	○	○

Acho que o *Anonymous Panda* pode ser útil para consultas de psicologia/psiquiatria I think *Anonymous Panda* can be useful for mental health therapy	○	○	○	○	○	○	○
Acho que o *Anonymous Panda* é fácil de usar I think *Anonymous Panda* is easy to use	○	○	○	○	○	○	○
Usar o *Anonymous Panda* é intuitivo Using *Anonymous Panda* is intuitive	○	○	○	○	○	○	○
Usar o *Anonymous Panda* permitir-me-ia alcançar uma saúde mental estável mais rapidamente Using *Anonymous Panda* would enable me to have a more stable mental health quickly	○	○	○	○	○	○	○
Aprender a utilizar o *Anonymous Panda* foi fácil para mim Learning how to use *Anonymous Panda* was easy for me	○	○	○	○	○	○	○
Usar o *Anonymous Panda* aumentaria a minha disposição de pedir apoio em termos de saúde mental Using *Anonymous Panda* would increase my willingness to ask for mental health support	○	○	○	○	○	○	○
Foi fácil conseguir que o *Anonymous Panda* fizesse o que eu queria que ele fizesse It was easy to get *Anonymous Panda* to do what I wanted it to do	○	○	○	○	○	○	○
Usar o *Anonymous Panda* tornaria mais fácil expressar os meus sentimentos Using *Anonymous Panda* would make it easier to express my feelings	○	○	○	○	○	○	○
A minha interação com o *Anonymous Panda* foi clara e compreensível My interaction with *Anonymous Panda* was clear and understandable	○	○	○	○	○	○	○

Conhece ou já utilizou alguma plataforma semelhante ao conceito da aplicação *Anonymous Panda*? Do you know or have ever used a platform similar to the *Anonymous Panda* app?

○ Sim (qual?) Yes (which one?) _____

○ Não No

Caso possua algum comentário adicional, por favor deixe-o aqui. Obrigado pela sua participação. If you have any additional comments, please write them here. Thank you for your help.

_____

_____

_____

_____

H Correlation Matrix

		I am confident others will not know who I am	I think someone may recognize me from my voice	I think someone may recognize me from the expressions or words I use frequently	I think someone may find out how old I am	I am afraid someone will find out who I am	I feel I am more willing to talk about my problems	I think Anonymous Panda could be useful for mental health therapy	Using Anonymous Panda would enable me to have a more stable mental health quickly	Using Anonymous Panda would increase my willingness to ask for mental health support	Using Anonymous Panda would make it easier to express my feelings	I am willing to talk about my family history and/or secrets	I am willing to talk about my failures	I am willing to express my most intimate feelings	I am willing to talk about my shameful experiences	I am willing to share things I wouldn't normally share with my family, friends and colleagues	I think Anonymous Panda is easy to use	Using Anonymous Panda is intuitive	Learning how to use Anonymous Panda was easy for me	It was easy to get Anonymous Panda to do what I wanted it to do	My interaction with Anonymous Panda was clear and understandable
I am confident others will not know who I am	Correlation Coefficient	1.000	-.119	.464*	.274	.291	.370	.563**	.179	.251	.208	.323	.522*	.111	.434	-.108	.477*	.348	.496*	.513*	.651**
	Sig. (2-tailed)	.	.618	.039	.242	.213	.108	.010	.449	.286	.378	.165	.018	.643	.056	.650	.033	.133	.026	.021	.002
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I think someone may recognize me from my voice	Correlation Coefficient	-.119	1.000	.506*	.405	-.114	.391	.001	.350	.233	.432	.385	.222	.209	.316	.387	-.110	.135	-.078	.061	-.129
	Sig. (2-tailed)	.618	.	.023	.076	.633	.088	.997	.130	.323	.057	.093	.347	.376	.175	.092	.645	.571	.745	.798	.587
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I think someone may recognize me from the expressions or words I use frequently	Correlation Coefficient	.464*	.506*	1.000	.696**	.341	.520*	.466*	.364	.407	.585**	.264	.355	.050	.280	.219	.325	.395	.345	.516*	.427
	Sig. (2-tailed)	.039	.023	.	<.001	.142	.019	.038	.115	.075	.007	.260	.125	.835	.231	.354	.162	.085	.136	.020	.060
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I think someone may find out how old I am	Correlation Coefficient	.274	.405	.696**	1.000	.331	.227	.272	.153	.335	.469*	.137	.058	.011	.249	.232	.353	.266	.342	.480*	.451*
	Sig. (2-tailed)	.242	.076	<.001	.	.154	.335	.246	.520	.148	.037	.564	.807	.963	.290	.326	.126	.256	.140	.032	.046
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I am afraid someone will find out who I am	Correlation Coefficient	.291	-.114	.341	.331	1.000	.225	.161	-.029	-.155	.051	.057	.138	-.061	.091	-.372	.257	-.068	.138	.214	.452*
	Sig. (2-tailed)	.213	.633	.142	.154	.	.341	.499	.904	.515	.830	.810	.563	.797	.702	.106	.273	.777	.561	.365	.045
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I feel I am more willing to talk about my problems	Correlation Coefficient	.370	.391	.520*	.227	.225	1.000	.659**	.635**	.393	.762**	.859**	.658**	.603**	.690**	.231	.409	.349	.475*	.159	.356
	Sig. (2-tailed)	.108	.088	.019	.335	.341	.	.002	.003	.087	<.001	<.001	.002	.005	<.001	.326	.073	.132	.034	.503	.123
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I think Anonymous Panda can be useful for mental health therapy	Correlation Coefficient	.563**	.001	.466*	.272	.161	.659**	1.000	.367	-.029	.051	.594**	.651**	.467*	.652**	.239	.775**	.443	.560*	.257	.492*
	Sig. (2-tailed)	.010	.997	.038	.246	.499	.002	.	.112	.908	.830	.006	.002	.038	.002	.311	<.001	.051	.010	.274	.028
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Using Anonymous Panda would enable me to have a more stable mental health quickly	Correlation Coefficient	.179	.350	.364	.153	-.029	.635**	.367	1.000	.738**	.692**	.568**	.307	.235	.343	.495*	.231	.391	.445*	.028	.130
	Sig. (2-tailed)	.449	.130	.115	.520	.904	.003	.112	.	<.001	<.001	.009	.188	.318	.138	.027	.327	.088	.049	.905	.585
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Using Anonymous Panda would increase my willingness to ask for mental health support	Correlation Coefficient	.251	.233	.407	.335	-.155	.393	.573**	.738**	1.000	.648**	.314	.182	.020	.242	.693**	.404	.478*	.502*	.271	.209
	Sig. (2-tailed)	.286	.323	.075	.148	.515	.087	.008	<.001	.	.002	.177	.443	.932	.305	<.001	.077	.033	.024	.247	.376
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Using Anonymous Panda would make it easier to express my feelings	Correlation Coefficient	.208	.432	.585**	.469*	.051	.752**	.596**	.692**	.648**	1.000	.638**	.502*	.452*	.045	.519*	.476*	.386	.489*	.479*	.320	.283
	Sig. (2-tailed)	.378	.057	.007	.037	.830	<.001	.006	<.001	.002	.	.002	.024	.045	.019	.034	.093	.029	.033	.169	.226
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I am willing to share my family history and/or secrets	Correlation Coefficient	.323	.385	.264	.137	.057	.859**	.594**	.568**	.314	.638**	1.000	.668**	.731**	.862**	.187	.398	.334	.374	-.094	.164
	Sig. (2-tailed)	.165	.093	.260	.564	.810	<.001	.006	.009	.177	.002	.	.001	<.001	<.001	.430	.082	.150	.104	.694	.489
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I am willing to talk about my failures	Correlation Coefficient	.522*	.222	.355	.058	.138	.658**	.651**	.307	.182	.502*	.668**	1.000	.571**	.798**	.204	.529*	.453*	.423	.268	.436
	Sig. (2-tailed)	.018	.347	.125	.807	.563	.002	.002	.188	.443	.024	.001	.	.009	<.001	.388	.016	.045	.063	.252	.054
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I am willing to express my most intimate feelings	Correlation Coefficient	.111	.209	.050	.011	-.061	.603**	.467*	.235	.020	.452*	.731**	.571**	1.000	.642**	-.052	.289	.135	.101	-.285	.044
	Sig. (2-tailed)	.643	.376	.835	.963	.797	.005	.038	.318	.932	.045	<.001	.009	.	.002	.826	.216	.569	.671	.224	.854
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I am willing to talk about my shameful experiences	Correlation Coefficient	.434	.316	.280	.249	.091	.690**	.652**	.343	.242	.519*	.862**	.798**	.642**	1.000	.248	.614**	.464*	.422	.061	.359
	Sig. (2-tailed)	.056	.175	.231	.290	.702	<.001	.002	.138	.305	.019	<.001	<.001	.002	.	.292	.004	.039	.064	.799	.120
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I am willing to share things I wouldn't normally share with my family, friends and colleagues	Correlation Coefficient	-.108	.387	.219	.354	.231	.162	.085	.136	.020	.248	.476*	.204	-.052	.248	1.000	.252	.541*	.344	.672**	.380	.407
	Sig. (2-tailed)	.650	.092	.354	.326	.106	.326	.311	.027	.404	.386	.398	.529*	.289	.614**	.	.283	.014	.001	.001	.099	.075
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
I think Anonymous Panda is easy to use	Correlation Coefficient	.477*	-.110	.325	.353	.257	.409	.775**	.231	.404	.386	.398	.529*	.289	.614**	.252	1.000	.677**	.593**	.672**	.305	.448*
	Sig. (2-tailed)	.033	.645	.162	.126	.273	.073	<.001	.327	.077	.093	.082	.016	.216	.004	.283	.	.001	.006	.001	.193	.002
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Using Anonymous Panda is intuitive	Correlation Coefficient	.348	.135	.395	.266	-.068	.349	.443	.391	.391	.478*	.334	.453*	.135	.464*	.541*	.677**	1.000	.672**	.380	.407
	Sig. (2-tailed)	.133	.571	.085	.256	.777	.132	.051	.088	.033	.029	.150	.045	.569	.039	.014	.001	.	.001	.099	.075
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Learning how to use Anonymous Panda was easy for me	Correlation Coefficient	.496*	-.078	.345	.342	.138	.475*	.560*	.445*	.502*	.479*	.374	.423	.101	.422	.344	.593**	.672**	1.000	.305	.448*
	Sig. (2-tailed)	.026	.745	.136	.140	.561	.034	.010	.049	.024	.033	.104	.063	.671	.064	.137	.006	.001	.	.190	.048
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
It was easy to get Anonymous Panda to do what I wanted it to do	Correlation Coefficient	.513*	.061	.516*	.480*	.214	.159	.257	.028	.271	.320	-.094	.268	-.285	.061	.322	.304	.380	.305	1.000	.731**
	Sig. (2-tailed)	.021	.798	.020	.032	.365	.503	.274	.905	.247	.169	.694	.252	.224	.799	.167	.193	.099	.190	.	<.001
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
My interaction with Anonymous Panda was clear and understandable	Correlation Coefficient	.651**	-.129	.427	.451*	.452*	.356	.492*	.130	.209	.283	.164	.436	.044	.359	.223	.647**	.407	.448*	.731**	1.000
	Sig. (2-tailed)	.002	.587	.060	.046	.045	.123	.028	.585	.376	.226	.489	.054	.854	.120	.345	.002	.075	.048	<.001	.
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).