Virtual Echoes: Enhancing Empathy Through the Experience of Others' Physiology in Emotional Virtual Scenarios

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Empathy is a soft skill that allows individuals to understand and share the feelings of others. Scientists have demonstrated that mirror neurons are responsible for empathy [1]. Empathy can cause a person to feel the pain of strangers or distant individuals as their own. Furthermore, research suggests that empathy plays a critical role in social cognition, enabling individuals to build trust and cooperate in complex social environments [2]. In an increasingly interconnected and diverse world, developing empathy is essential. This skill not only helps in personal relationships but also in professional settings, as it facilitates communication and collaboration among individuals.

However, constant exposure to tragic images and stories provided by the media can have a desensitizing effect on empathy [3]. Despite being constantly informed about global crises, information saturation can lead to emotional disconnection. This phenomenon, often referred to as "compassion fatigue," has been widely studied, particularly in healthcare professionals and humanitarian workers, where the emotional toll of constant exposure to distress can inhibit empathetic [4].

Virtual Reality (VR) is a powerful tool for enhancing empathy. VR enables a deep understanding of others' perspectives and emotions due to its immersive capability. Exposure to virtual scenarios fosters strong emotional connection and encourages reflection on the experiences of others. For example, studies have demonstrated that VR experiences simulating the perspective of marginalized groups or individuals suffering from specific hardships can significantly increase empathetic engagement and reduce biases [5].

Techniques such as biofeedback offer a promising approach to further enhance empathy in such scenarios. Biofeedback is a technique that allows individuals to look at their physiological data in real-time, such as Heart Rate (HR) or skin perspiration. This enables the individual to understand how their body reacts to specific stimuli. Similarly, they can see the physiological data of another person to understand how that person feels at a given moment. This scenario strengthens understanding and empathetic response in interpersonal interactions.

The "Virtual Echoes" Project

The main objective of this project is to develop an immersive VR application that enables the measurement, understanding, and enhancement of empathy through direct experience of disaster situations. The application is designed to immerse users in catastrophic scenarios (such as natural disasters, fires, etc.) where they can realistically and emotionally experience the impacts of such events. During this project, empathy will be measured by using users' physiological data (such as, HR) and observing their emotional reactions. Additionally, emotional understanding will be promoted through the narrative of heartbreaking first-person stories. It is expected that the immersive capacity of VR will positively influence individuals' emotional connection with the victims of these disasters [3]. Finally, the project aims to foster reflection, not only by understanding the effects of disasters but also by internalizing the importance of empathy in difficult situations.

The VR application will be structured in three levels, each designed to progressively immerse users in a disaster scenario and measure their empathetic response in different ways.

Level 1: Presentation of Objective Data

In this phase, users will receive objective information about the disaster (e.g., meteorological data, quantitative data on the effects of the disaster, aerial images or 360° videos of the affected areas, etc.), providing an overview of the scale of the event. During this level, the users' physiological responses will begin to be measured to observe whether the presentation of these data influences their emotions. For the creation of this first level, archival images, aerial footage of the affected area, or 360° videos of specific locations could be used. Presenting objective data alongside visual content has been shown to evoke an emotional response by contextualizing the magnitude of disasters [6].

Level 2: Interaction in a Small-Scale Scenario

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In this level, users will have the opportunity to explore a more intimate environment, such as a flooded home or a damaged building. In this virtual setting, interacting with objects representative of the catastrophe (e.g., wet furniture, debris, personal belongings) will allow them to emotionally connect with the tragedy. From this level onwards, users will have access to their own physiological data, enabling them to observe their real-time reactions to these situations. The development of this level will require a higher level of detail to ensure that users feel fully immersed. Depending on the scenario, stereoscopic 360° photos and videos could be captured to provide a 3D sensation. Photogrammetry of the site could also be performed, followed by a virtual reconstruction using 3D modeling and realistic texturing programs. Incorporating personal objects has been found to elicit stronger empathetic responses, as these items symbolize emotional loss [7].

Level 3: Interview with a Victim

The final level will present an interview with a disaster survivor, who will share their firsthand experience. Through asynchronous interaction, the physiological data of the interviewee will be displayed alongside the user's data to compare the emotions generated. An empathy indicator will allow the user to reflect on their emotional responses and their level of connection with the affected individual. In this level, the user should feel that the interviewee is speaking directly to them, making stereoscopic 360° video the most suitable technology [3]. Over this video, both individuals' physiological data and the empathy indicator will be projected.

The biofeedback system will capture the user's HR data in real-time and display it live during levels 2 and 3. In the final level, the interviewee's data will also appear asynchronously. This means that the data will be recorded in real-time during the interview but will be displayed when the individual uses the application. The application will compare the physiological data of both individuals to assess whether the user's mirror neurons respond to the interviewee's emotions in a similar way. These data will generate an empathy indicator that will be available to the user at all times.

This application is not intended to serve as a stressor for individuals or to rely on sensationalism. At no point will compromising or graphic images be shown; instead, the focus will be on illustrating the consequences of various disasters, primarily on locations and physical objects. Throughout the entire process, users will be accompanied by a psychology professional and will have the option to consult them if needed.

Scenario Proposal: DANA in Valencia (Spain) – October 2024

The Isolated Depression at High Levels (known as DANA in Spanish) that impacted the Valencian Community (Spain) in October 2024 was one of the most devastating meteorological phenomena in the region in recent decades. Starting on October 29, intense rainfall caused catastrophic flooding in various localities, particularly in the province of Valencia. The tragic toll of the DANA event was at least 215 fatalities in the Valencian Community, with 211 victims in the province of Valencia. Additionally, dozens of people were reported missing, and numerous others were injured. The floods caused the destruction of homes, damage to infrastructure and vehicles, and severely impacted the local economy.

Given the significant impact of this event on Spanish society, the proposal is to develop a VR experience that allows individuals to live firsthand the effects of this climatic disaster and its consequences.

This scenario will include three levels as described earlier. In the first level, general images and videos of the affected areas will be displayed alongside striking visuals of the consequences of the floodwaters. Additionally, objective data will be presented, such as maps to locate the most affected towns, statistics on victims, missing persons, and injuries, as well as economic impacts. These resources will combine archival images and videos with footage captured on-site.

For the second level, the interior of a home devastated by the DANA will be digitally recreated. Stereoscopic 360º videos and photogrammetry of a real house will be conducted, and archival images of how homes and establishments appeared after the flooding will be used as references. Once all references are gathered, the space and objects with which individuals can interact (e.g., photo albums or children's toys) will be designed and modeled in 3D for a greater immersion and feeling of familiarity [8]. These objects will help place the individual in a more personal context and attempt to convey how the family might have lived before the disaster and how they might feel after losing all their memories to water and mud.

Finally, in the third level, the individual will listen (and see) the testimony of one of the DANA victims in the first person. The physiological information of the person sharing the story will also be available, enabling the user to understand how heart rate relates to emotional states. This interview will be conducted prior to the creation of the second level, ensuring that the scenario reflects the interviewee's testimony as accurately as possible. In this way, the individual will feel a stronger emotional connection to the story by having virtually "been" in the setting described.

Expected Outcomes and Future Research Directions

This project aims to develop an innovative VR application to help individuals enhance the soft skill of empathy. Additionally, the application can serve as an educational resource to raise awareness about the effects of disasters.

The application will be developed by XRAI Lab, a team of experts in virtual application development from the University of Burgos (Spain). The project will be supervised by a group of psychologists from the University Health Services of the same institution.

The development process will be divided into multiple phases. At present, the conceptual design phase has been completed, during which an initial scenario and the general interactions and narratives of the project were defined. In the coming months, the first scenario, focused on the

DANA in Valencia, will be developed. This scenario will include the three proposed levels, incorporating archival images, 360° videos, virtual reconstructions, and other necessary resources. During this phase, the biofeedback system will also be developed and integrated into the application. Additionally, questionnaires will be defined to measure both initial empathy levels and the emotional state of the users. Subsequently, a preliminary validation will be conducted with a group of users to identify technical errors and fine-tune the immersive experience. Finally, a broader validation will be carried out with a diverse population group, including citizens unconnected to the disaster, healthcare professionals, volunteers, and others, to compare differences among groups.

Using the physiological data extracted from the application and the results from the questionnaires, patterns will be analyzed with the aid of artificial intelligence models. These patterns will provide deeper insights into how empathy functions in such situations and will also help refine the previously discussed empathy indicator. In the future, the possibility of extracting additional physiological data, such as eye-tracking or electrodermal activity, will be considered.

If the research yields promising results, the application could be expanded to address other social issues, such as migration, discrimination, or climate change. It could also serve as part of a professional training program in soft skills or in educational environments, contributing to the development of psychosocial skills across various sectors.

This approach not only seeks to implement an innovative short-term solution but also aims to lay the groundwork for ongoing research into new ways of promoting and measuring empathy in diverse contexts.

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