Computers in Human Behavior

Virtual Reality supports Perspective Taking in Cultural Heritage Interpretation: Results from a Pilot Study

--Manuscript Draft--

Manuscript Number:	CHB-D-23-00629
Article Type:	VSI: EmergTech n Human Beh
Section/Category:	Full Length Article
Keywords:	virtual reality; Social Cohesion; Interpretation-Reflection Loop; Artificial Intelligence; Embodied Experience; Virtual Embodiment
Abstract:	Based on studies concerning the possibility of evoking emotional responses in virtual environments (Meuleman and Rudrauf, 2018) arousing the sense of empathy (Ventura et al., 2020), our research aims to employ virtual reality (VR) technology to encourage users to adopt an alternative point of view through a virtual embodiment. This adoption should increase social cohesion, through a data-centric system based on a communication between the VR system and an Artificial Intelligence. We verified the validity of the hypothesis about the possibility of using VR to encourage users to adopt another point of view. To this end, we built a virtual museum where different avatars can interact with experimental subjects to discuss emotional and value-driven interpretations related to artworks, aiming at bootstrapping user's interpretation-reflection loops (IRL) (Daga et al., 2022). IRL consists in encouraging the user to provide a point of view; to know about another point of view; and to possibly take a different perspective. In line with recent literature, our results are based on the analysis of dialogue, and of psychophysiological response of the users, showing that a VR-driven methodology can develop a sense of embodiment, and maximize the human capacity to take another's point of view. Results allow us to confirm that the use of immersive VR can be a valid tool to promote empathy through an embodied experience, therefore the use of an AI able to modify the avatar profile based on the user profile can be an innovative measure to promote social cohesion.

Highlights

1. Virtual Reality methodology can promote the social cohesion among users, through virtual embodiment
2. During virtual embodiment the percentage of people that change their interpretation according to the avatar's interpretation is higher than people who don't change it
3. Empathic people show an increase of the emotional involvement when they dress the shoes of another person/avatar
4. Automatic language inference systems are able to detect the emotions and moral values from verbal speech of human subjects with a good accuracy

Title

Virtual Reality supports Perspective Taking in Cultural Heritage Interpretation: Results from a Pilot Study

Abstract

Based on studies concerning the possibility of evoking emotional responses in virtual environments (Meuleman and Rudrauf, 2018) arousing the sense of empathy (Ventura et al., 2020), our research aims to employ virtual reality (VR) technology to encourage users to adopt an alternative point of view through a virtual embodiment. This adoption should increase social cohesion, through a data-centric system based on a communication between the VR system and an Artificial Intelligence.

We verified the validity of the hypothesis about the possibility of using VR to encourage users to adopt another point of view. To this end, we built a virtual museum where different avatars can interact with experimental subjects to discuss emotional and value-driven interpretations related to artworks, aiming at bootstrapping user's *interpretation-reflection loops* (IRL) (Daga et al., 2022). IRL consists in encouraging the user to provide a point of view; to know about another point of view; and to possibly take a different perspective.

In line with recent literature, our results are based on the analysis of dialogue, and of psychophysiological response of the users, showing that a VR-driven methodology can develop a sense of embodiment, and maximize the human capacity to take another's point of view. Results allow us to confirm that the use of immersive VR can be a valid tool to promote empathy through an embodied experience, therefore the use of an AI able to modify the avatar profile based on the user profile can be an innovative measure to promote social cohesion.

Keywords: Virtual Reality; Social Cohesion; Interpretation-Reflection Loop; Artificial Intelligence; Embodied Experience; Virtual Embodiment

1. Introduction

Although humans are evolutionary social animals, dedicated to teamwork, collaboration and prosocial behavior (Tomasello, 2014), today there is apparently a decrease in the quality and quantity of social relations in industrialized societies (Holt-Lunstad et al., 2010; McPherson & Smith-Lovin, 2006; Putnam 2000), and these data appear to be dangerous for human life. Indeed, in a meta-analytic report Holt-Lunstad and colleagues (2010) reported that social relationships significantly predict mortality, there appears to be a 50% increase in the chances of survival in relation to social relationships (Holt-Lunstad et al., 2010).

Already in 1988, in an article published in Science, House et al. state that "Social relationships, or the lack thereof, constitute a major health risk factor, rivaling the effect of established health risk factors such as cigarette smoking, blood pressure, blood lipids, obesity and physical activity" (House et al., 1988) Recent studies show that in older people social isolation is related with a 29% increase in risk of death (Holt-Lunstad & Smith, 2015), 29% increase in heart disease and 32% increase in risk of stroke (Valtorta et al., 2016). As well as, in middle-aged communities, social isolation appears to be an added risk factor of death and morbidity (Naito et al., 2021).

Social exclusion, and therefore social isolation, can be understood as the perception of being physically and / or emotionally distant from others (Wesselmann et al., 2016), and it is mainly characterized by rejection (being denied) or by ostracism (being ignored). In both cases, social pain has a strong impact on people's thoughts, emotions, and behaviors (Riva & Eck, 2016) increasing the desire for aggression (Riva, et al., 2011).

In this direction, our research aims to use Virtual Reality as a new tool to encourage users to adopt an alternative point of view through a virtual embodiment, in order to increase social cohesion. Today, technologies and digital are increasingly at the center of people's lives and influence their individual experiences and social interactions. In this sense, the use of technologies represents an emerging field of study capable of facilitating social interactions and promoting the psychological well-being of people in social contexts (Pancani, 2020).

In particular, the use of immersive virtual environments has proved to be very useful in the psychological field in reference to the area of social interactions (Blascovich, et al., 2002; Loomis et al., 1999). An example is Cyber-PsychoTherapy, which can be defined as the use of innovative technologies that help traditional psychology (Ventura et al., 2018) allowing the subjects to experience real situations perceiving their own body within a simulated and safe environment (Lucifora et al., 2021).

In the field of Cognitive Science, recent studies have shown that virtual reality can increase prosocial behavior (Schutte and Stilinović, 2017) and arouse empathy among users (Ahn et al., 2013; 2016).

For example, Jackson and colleagues (2015) demonstrated the usefulness of a non-immersive virtual reality in arousing a sense of empathy by monitoring the user's physiological response in observing faces expressing positive and negative emotions; Ahn and colleagues (2013) used embodied experience to elicit favorable attitudes towards people with disabilities; and Asher and colleagues (2018) used virtual reality to elicit a sense of empathy towards the homeless.

Recent research by Kishore et al. (2022) related to the study of implicit prejudice and aggressive racist behavior, shows that exposure to virtual reality, operating at the implicit level, can combat the aggression rooted in implicit prejudice. Hamilton-Giachritsis et al. (2018) used immersive virtual reality to elicit a sense of empathy and cognitive awareness of another individual's status in the parenting relationship. Furthermore, VR self-counseling studies (Osimo et al., 2015) that allow the users to incarnate in different people have also proved to be particularly effective in this line.

Our research emerges from case studies in the H2020 SPICE project (Social Cohesion, Participation, Inclusion through Cultural Engagement), which aims at the development of suitable technologies to share the interpretations of artifacts and other museum objects. Our research aims to encourage the user to discuss emotional and value-driven interpretations related to works of art, bootstrapping user’s *interpretation-reflection loops*, through a virtual embodiment experience.

2. Material and Methods

2.1.Participants

Our experimental sample consists of university students. The sample is made up by 44 subjects, divided in two groups of 22 subjects.

The first group is made up by 6 males and 16 females with an average age of 26 years old, while the second group is made up by 7 males and 15 females, with an average age of 27 years old.

On a total sample of 53 subjects, 9 were excluded for missing data due to a system error. All subjects participated voluntarily, and their data were collected anonymously. The Ethics committee of the Department of Cognitive Science approved the protocol (number: COSPECS_05_2022).

2.2.Instruments

In our experimental design we have recreated an immersive virtual environment to simulate a visit in a Museum of Art. We used immersive virtual reality, which isolates the user's perceptual channels to induce feelings of telepresence (Steuer, 1992), given by the possibility of performing real movements (e.i. walking, touching, interacting with people and / or objects), and placing one's body as an active part of the virtual world.

To this end, we used a VR headset made by Oculus, namely Oculus Quest2, equipped with rotation, position, and body tracking sensors, as well as integrated headphones that provide a 3D sound effect.

We built the virtual environment using the computer graphics platform Unity Engine 3D, based on the "Blue Dot Studios- Art Gallery" scenario. We have added to this scenario, specific works of art from the Gallery of Modern Art (GAM) Museum. About the avatars, we created them using "ready player.me" and used "mixamo.com" for the animations.

To record the personal interpretation of the subjects, we used a Zoom H2n audio recorder, and transcribed the dialogue using a semi-automatic "speech to text" methodology[1].

[1] Currently, we are working to implement an automatic speech-to-text methodology

Furthermore, for the study of empathy we used an equipment for physiological detection (Biosignal Plux Kit), which records the electrodermal activity (EDA) related to the skin micro-sweating, as a direct and immediate manifestation of a state of personal arousal (Bouscein, 2012) - Figure 1. We recorded the skin conductance response to record changes in sweat secretion activity as a result of the change of the sympathetic nervous system activity. We used 2 AgCl electrodes placed on the index and middle fingers at 1000Hz sampling rate.
We did not record heart rate and respiratory rate because of surrounding noise due to users speaking and movement, which would invalidate the measurements.

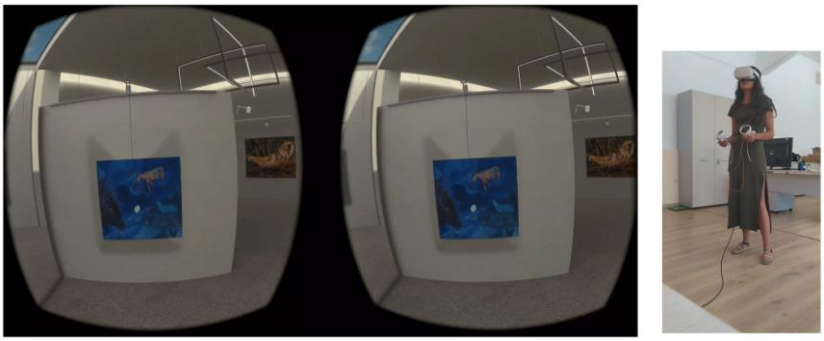


Figure 1: On the left: Virtual Reality environment (using Art Gallery - Unity Engine 3D).
On the right: Experimental setup (using BiosignalPlux kit and Oculus Quest 2)

On the other hand, to measure both cognitive and affective empathy we administered the Interpersonal Reaction Index (IRI) and the Empathy Components Questionnaire (ECQ) in a counterbalanced manner.
The IRI test (Davis, 1980) consists of 28 questions on a 5-point Likert scale. It consists of four scales: Fantasy (tendency to transpose oneself in an imaginative way into fantasy situations), Perspective Taking (tendency to spontaneously adopt the psychological point of view of others), Empathic Concern (exploits feelings of warmth, compassion and concern for others), and Personal Distress (evaluates feelings of self-directed anxiety and discomfort resulting from interpersonal contexts).
The ECQ test (Batchelder, et al., 2017) is made up by 27 items, based on a Likert Scale from 0 (totally in disagree) to 4 (totally agree) and assess the

cognitive ability, cognitive drive, affective ability, affective drive and affective reactivity.

Furthermore, we measured the personal degree of alexithymia, understood as "the absence of words for emotions" (Nemiah and Sifneos 1970), that is a stable personality characteristic related to an affective processing disorder (Taylor and Bagby, 2012). For this purpose, we used the Toronto Alexithymia Scale TAS-20 (Taylor et al., 1992) consisting of 20 questions on a 5-point Likert scale.

Finally, based on what has been denoted by previous studies (Van Loon et al., 2018) regarding the positive relationship between empathy and immersion in the virtual environment, we used the Presence Questionnaire PQ (Witmer et al., 2005), consisting of 24 questions on a 7-point Likert scale, aimed at understanding the degree of perceived immersion. All these tests have been recreated and administered via an online Google Form.

2.3.*Procedure*

2.3.1. Dataset

First, in order to ensure social cohesion, we collected the emotional and value interpretations provided by visitors at the GAM Museum.

We interviewed 37 subjects from 7 to 70 years old, parameterized on age, gender and nationality. To avoid collecting invalid information, we asked specific questions to the visitors, two with open answers (Q1 and Q2) and two with closed answers (Q3 and Q4) relating to the emotions and values that a specific work of art can arouse (See Table 1). For emotion categories we used the well-known Ekman's model (Ekman, 1999) with six universal emotions concerning happiness, sadness, disgust, fear, anger and surprise; while for value categories we used the standard classification of Haidt et al. (2012) including Care/Harm, Fairness/Cheating, Loyalty/Betrayal, Authority/Subversion, Sanctity/Degradation.

N	Questions
Q1	How does this work of art make you feel?
Q2	What moral value does this work of art inspire you?
Q3	Among these emotions (Ekman's model) which do you think the work of art arouses?
Q4	Among these moral values (Haidt''s model) which do you think the work of art arouses?

Table 1: Questions posed to the visitor during data collection at the GAM Museum

We interviewed visitors on 9 works of art dating back to the 1900s, parameterized into abstract, figurative and realistic works (See table 2). The visitors' emotional and value-driven interpretations, combined with their metadata (age, gender, nationality) were used for the creation of virtual avatars.

N	Title	Author	Classification
1	The three windows	Jessie Boswell 1924	Realism
2	Summer	Felice Carena 1933	Realism
3	Angles	Jean Faurtrier 1958	Abstract
4	Composition	Mario Mafai 1932	Figurative
5	Self-Portrait in the form of an owl	Alberto Savinio 1936	Figurative
6	In my country	Marc Chagall 1943	Abstract
7	Red head woman	Amedeo Modigliani 1915	Realism
8	The Gibigianna III	Giuseppe Gallizio 1960	Abstract
9	The Gibigianna VIII	Giuseppe Gallizio 1960	Abstract

Table 2: Works of art used for the data collection at the "GAM" Museum

Among all the works of art tested at the GAM, we included in the virtual environment those with a strong emotional interpretation. Therefore, we excluded "The Gibigianna III " and "The Gibigianna VIII" because they did not collect relevant answers and "The three windows" because they did not arouse relevant emotional interpretations. Table 3 shows the works of art that were included in the experimental phase, their avatars and the emotional and value interpretations provided by the visitors at the GAM museum. We used a total of 6 artworks accompanied by 6 avatars distributed in two experiments.

Artwork	Avatar (nationality, age, gender)	Emotion	Moral Value	Experiment
Angles (Faurtrier, 1958)	Italy, 21 male	Sadness	Purity/Degradation	1
Composition	Brazil, 30 male	Happiness	Fairness/Cheating	1

(Mafai, 1932)			Loyalty/Betrayal	
Summer (Carena, 1933)	Italy, 7 female	Sadness / Happiness	Care/Harm	1
In my country (Chagall, 1943)	Italy, 50 female	Surprise / Sadness	Care/Harm Purity/Degradation	2
Self-portrait (Savinio, 1936)	Morocco, 18 female	Surprise / Fear	Authority/Subversion	2
Red head woman (Modigliani, 1915)	Italy, 40 male	Sadness	Purity/Degradation	2

Table 3: Works of art used in the virtual environment, with related avatars, emotions and values.

2.3.2. Experimental Study

The experiment required participants to visit a virtual museum with the aim to give their personal interpretation on three works of art. The order of presentation was randomized for each group.

Before the VR experiment, the user was asked to complete the TAS-20 and one of the empathy tests (IRI or ECQ) and to provide his personal information like age, gender, and nationality. After the VR test, the user was asked to complete the other empathy test (IRI or ECQ) and the PQ test.

Inside the virtual museum, the user meets other visitors (virtual avatar) and can listen to their interpretation. The task is based on "perspective giving" related to a verbal and explicit reflection on the other's thought and on "perspective taking" related to the possibility of adopting the other's point of view, embodying the avatar (figure 2).

Figure 2: Virtual embodiment. The subject can touch and look at his/her new body and look in the mirror. There is a synchronization between the virtual and real movement of the body

We conducted two different experiments, in order to understand how the assumption of perspective can influence the interpretation-reflection loop of the subjects. While in the first experiment perspective taking is anticipated by the verbal reflection of the user about the interpretation of the avatars, in the second experiment the verbal reflection follows perspective taking (Figure 3AB). Furthermore, to exclude a possible influence due to the specific character of the avatars as well as the specific character of the works of art, we used different stimuli for each experiment, balancing the main variables of age, gender and nationality, as well as the abstract, figurative and realistic art movements.

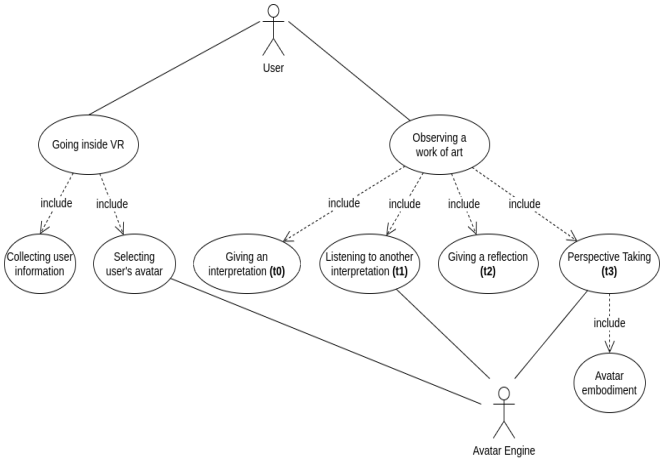
Experiment n.1

The first experimental group was subjected to the condition "*from reflection to perspective taking".*

First, we asked the user to complete the TAS-20 and an empathy test (IRI or ECQ counterbalanced).

Then, the user was placed inside the virtual museum with the aim of observing three works of art and providing a personal interpretation (time *t0*).

As in the real recording at the GAM museum, here the researcher asked the 4 questions to the users (see table 1). At the following time *t1* (listening), each work of art was given the emotional interpretation provided by other users (recorded at the GAM museum in Turin) expressed verbally by the avatars present in the scene.



A

B

Figure 3: Use case diagram (A) and Flowchart (B) of the experiment.

At time *t2* (reflection), the user was invited to discuss with the avatar, providing a further interpretation of the artwork. And at the last time *t3* (perspective taking) the user "dresses the shoes" of the avatar. Here the researcher asked again the personal interpretation of the subject following the four questions, explained above. At the end, the user was asked to complete the ECQ or IRI test and PQ test.

In this experiment we used three works of art with three avatars, that are explained in the table below (Table 4). All the works of art were administered in a random way to avoid a possible influence related to the presentation's order.

Work of art	Avatar	Metadata	Emotions	Moral Values	Interpretation
ANGLES (Jean Fautrier 1958) 		Italy 21 Male	Sadness	Sanctity/Degradation	It gives me coldness because there is a few of color. It gives me coldness and distance
COMPOSITION (Mario Mafai 1932) 		Brazil 30 Male	Happiness	Fairness/cheating Loyalty/ Betrayal	I'm curious because they play naked and seem calm. I am happy, I would like to be with them
SUMMER (Felice Carena 1933) 		Italy 7 Female	Sadness Happiness	Care / Harm	I think maybe she was wrong and was punished, but she also reminds me of fairy tales and fantasy

Table 4: Stimuli (artworks and avatars) administered in the first experiment

Experiment n.2

The second experimental group was subjected to the condition *"from perspective taking to reflection"*.

Before the virtual task, the user was asked to complete the TAS-20 and IRI or ECQ test (counterbalanced).

In this case, the procedures of group 1 are kept stable at time *t0* and *t1*, while at time *t2*, the user was invited to provide a further interpretation of the work of art, finding himself in the role of the avatar. At the last time *t3* the user was invited to discuss with the avatar to provide his personal reflection on the artwork. At the end, the user completed the IRI or ECQ test and PQ test.

In this experiment we used three works of art with three avatars, that are explained in the table below (Table 5). Like in the first experiment, all the works of art were administered in a random way.

Work of art	Avatar	Metadata	Emotions	Moral Values	Interpretation
IN MY COUNTRY (Marc Chagall 1943) 		Italy 50 Female	Sadness Fear	Sanctity/Degradation	It has a dreamlike sense. It gives me a sense of protection because I see two people hugging
SELF-PORTRAIT IN THE FORM OF AN OWL (Alberto Savino 1936) 		Morocco 18 Female	Surprise Fear	Authority/Subversion	it seems that the author wanted to represent himself and his interior with something external
RED HEAD WOMAN (Amedeo Modigliani 1915) 		Italy 40 Male	Sadness	Sanctity/Degradation	I see hypocrisy because it has an asymmetrical gaze, one that observes and the other that does not want to see

Table 5: Stimuli (artworks and avatars) administered in the second experiment

3. Data Analysis and Results

In order to understand if a VR-driven methodology can induce a sense of embodiment and maximize the human capacity to take another's point of view, we performed an empathic analysis of the dialogue, comparing the interpretation at time t0 and t2/t3, as well as the biopsychological response (EDA) as an index of empathic involvement.

Our results derive from five methods, summarized as follows:

1. First, categorial analysis helps us distinguish three categories of subjects (empathic people, partially empathic people and non-empathic people) in both experimental groups, and confirms the power of virtual embodiment in arousing empathy among users (paragraph 3.1)
2. Automated speech analysis reveals that automated language inference systems are sufficient to detect emotions and moral values from the verbal speech of the users (paragraph 3.2)

3. Verbal reaction time analysis lets us hypothesize a correlation between the virtual embodiment and the fast thinking related to self-reflection (paragraph 3.3)

4. Psychophysiological analysis related to the electrodermal activity shows a significant correlation between the emotional involvement of the users and their empathic attitude (paragraph 3.4)

5. Correlation between self-report questionnaires related to empathy and the perception of presence in the virtual embodiment confirms the Proteus Effect and its connection to cognitive and affective empathy (paragraph 3.5)

3.1. Categorial Analysis

Concerning the interpretation-reflection loop, based on the emotional and value categories provided by the users during the VR experience, we considered all the interpretations at time *t0* and *t2/t3*. We compared the answers to Q3 and Q4, related to the classification of emotions and values and the personal interpretation / reflection.

Our results show that in both experimental groups it is possible to distinguish three types of subjects, which either change or not their interpretation when they dress another person's body:

(1) Non-empathic: subjects that don't change their interpretation, as well as their emotions and values

(2) Moderately empathic: subjects who only change the value or the emotion

(3) Empathic: subjects who totally change their interpretation, including emotions and values.

In both experimental groups the percentages of empathic subjects (totally or partially) are equal or greater than non-empathic subjects (Figure 4).

The Chi-square analysis within subjects shows a significant difference in both experiments (experiment n.1 p-level 0.007; experiment n.2 p-level 0.016).

The Chi-square analysis between subjects shows that the frequency of empathic people is higher in the experiment n.2 (p-level 0.018).

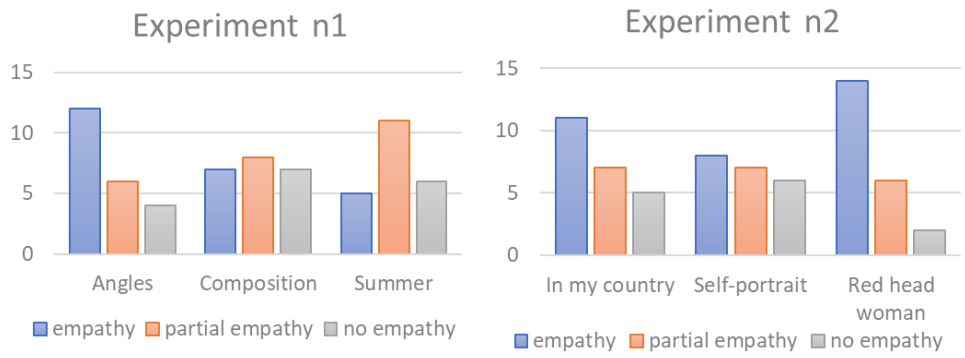


Figure 4: This chart shows that in both experiments the percentage of those who empathize with the emotional-value interpretation of the avatars is higher than who don't empathize. These differences are statistically significant. (Experiment n.1 Chi-Square within subjects p-level 0.007; Experiment n.2 Chi-Square within subjects p-level 0.016; Chi-Square between subjects p-level 0.018)

In addition, about the emotion / value that was implicitly induced through the avatar's dialogue, the subjects present a high degree of agreement for each artwork (Table 6AB). The avatar speech is related to specific emotions and moral values, but they are not explicit in the dialogue. The differences between shared and not shared emotions and values is statistically significant (Emotions, Chi-Square p-level 0.0009; Moral values Chi-Square p-level <0.00001)

Group 1							
Work of Art	Sadness	Happyness	Anger	Fear	Disgust	Surprise	None
1	**31%**	6%		19%	19%	**19%**	6%
2	9%	**37%**	18%	9%		**27%**	
3	**33%**	17%		33%		17%	
Group 2							
1	**36%**	29%				**36%**	
2		15%	23%	**15%**	**31%**	15%	
3	**60%**		13%	7%		20%	

A

Group 1						
Work of Art	Care/Harm	Fairness/cheating	Loyality/Betrayal	Authotity/Subversion	Sancity/Degradation	None
1	9%	18%	9%	18%	**36%**	
2		**30%**	**40%**	20%	10%	
3	**56%**	6%	12%		**29%**	
Group 2						
1	**46%**		38%	8%	8%	
2		**37%**	25%	12%	25%	
3	**29%**	21%	7%	**29%**	14%	

B

Table 6: the emotions (A) and moral values (B) that we have induced through dialogue is marked in red. The percentages indicate the degree of agreement of the users.

(Emotions Chi-Square p-level 0.0009; Moral values Chi-Square p-level <0.00001).

In a general speech analysis, we compared the interpretations of the subjects at all phases (t0, t2, t3). In this case, it is possible to notice an interesting result on non-empathic people, related to the difference between the reflection phase (t2) and the perspective taking phase (t3) in the first experimental group. Here, in the perspective taking phase, the people who do not change their interpretation are fewer than the people who affirm a non-empathic interpretation in the reflection phase (Figure 5). This means that the power of virtual embodiment allows the user to change their interpretation even if they don't change interpretation in the preliminary reflection phase. This data is present only in one case in the second experimental group in which perspective taking occurs before reflection, here the number of non-empathic subjects is lower. This result confirms that the virtual embodiment has a great influence on the interpretation-reflection loop.

Experimental Group n.1

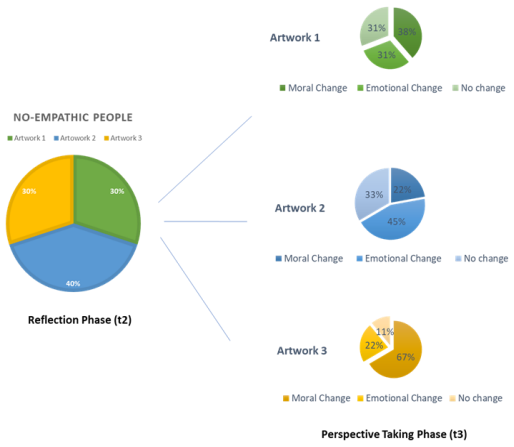


Figure 5: This chart shows the percentage of non-empathic people in the reflection phase (on the left) and the percentage of people that change their emotions and/or moral values in the perspective-taking phase (on the right) in the experimental group n.1.

3.2.Automated speech analysis

Furthermore, we did an emotional-value detection on Q1 and Q2, using two automatic language inference systems, that are Zero-Shot and FRED, with the aim to detect emotions and moral value through the speech of the users.

Zero-shot is an unsupervised language model (Asprino et al., 2022), trained to make inferences starting from a prompt acting as inferential premises; while

FRED (Gangemi et al., 2017; 2022) is a machine reader capable of analyzing text in natural language and transforming it into a knowledge graph of linked data.

Here we divided our samples in three categories, that are:

- Irrelevant: subjects that in Q1 and Q2 don't give informations related to emotions or values
- Incoherent: subjects who state a specific emotion or value in Q1 and Q2 but annotated another one in Q3 and Q4
- Coherent and Relevant: subjects with a clear emotion/value interpretation both in Q1/Q2 then in Q3/Q4

Our results show that both automatic language systems are able to detect the emotions and moral values of coherent people, with a good accuracy. This result is confirmed in any phase (*t0, t2, t3*) in both experimental groups, however the Zero-shot system allows a more accurate detection - Table 7.

Emotions

	Group n. 1			Group n. 2		
	t0	t2	t3	t0	t2	t3
Relevant	0.72	0.62	0.70	0.56	0.56	0.47
Irrelevant	0.26	0.05	0.26	0.11	0.20	0.09
Incoherent	0.19	0.18	0.13	0.06	0.25	0.20

Moral Values

	Group n. 1			Group n. 2		
	t0	t2	t3	t0	t2	t3
Relevant	0.48	0.49	0.35	0.38	0.32	0.29
Irrelevant	0.09	0.30	0.42	0.18	0.10	0.33
Incoherent	0.27	0.30	0.33	0.18	0.32	0.19

A

Emotions

Group n. 1	Group n. 2				
t0	t2	t3	t0	t2	t3
Relevant 0.38	0.37	0.35	0.47	0.45	0.36

Irrelevant	0.17	0.01	0.00	0.19	0.03	0.08
Incoherent	0.11	0.05	0.24	0.12	0.00	0.00

Moral Values

Group n. 1			Group n. 2			
t0	t2	t3	t0	t2	t3	
Relevant	0.02	0.20	0.20	0.07	0.18	0.16
Irrelevant		0.00	0.02	0.00	0.03	0.02	0.14
Incoherent		0.11	0.07	0.03	0.00	0.10	0.00

B

Table 7: this table shows the micro and the weight of f1-score in the three categories (irrelevant, incoherent and coherent and relevant) for each phase (t0, t2, t3) related to emotions and moral values, detected through Zero-shot (A) and FRED (B).

This result allows us to confirm the possibility of using an automatic system to detect emotions and moral values through the speech of the users (ongoing research).

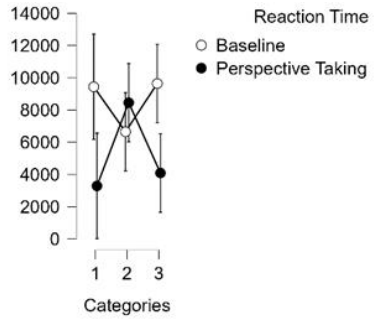
3.3.Verbal reaction time analysis

Finally, we analyzed the verbal reaction time index (RT) for each participant to understand if empathy is linked to rapid response from the participants, or if, contrary, empathy is expected to take more time.

We analyzed the reaction time for each artwork, for each participant, using ELAN 6.4. as software. Then we extracted an index related to the difference between t0 and t2/t3. We excluded outliers over 2.5SD from our analysis.

Our results show that the reaction time is not linked to the ability to change one's own personal interpretation, but it is linked to the virtual embodiment. In fact, to take another point of view before a verbal and explicit reflection on it (experiment n.2) leads to an immediate response that significantly reduces the verbal reaction time in both no-empathic then empathic people (t-test analysis shows significant differences in category 1:p-level 0.007; and category 3: p-level 0.001). Instead, to be partially in agreement with the feelings of others requires more time, which increases the verbal reaction index in the perspective taking phase (this result is obtained by subtracting the perspective taking phase

to the baseline of each participant. Repeated measures ANOVA p-level 0.008). - Figure 6.



Descriptives

Reaction Time	Categories	Mean	SD	N
Baseline	1	9438.889	5855.338	9
	2	6649.474	2981.020	19
	3	9642.258	7901.840	31
Perspective Taking	1	3291.111	2054.388	9
	2	8456.316	7179.397	19
	3	4092.258	4820.382	31

Figure 6: Repeated measures ANOVA show that verbal reaction time in the experiment n.2, increase in moderately empathic people (category 2) and decrease in empathic people (category 3) and no-empathic people (category 1) in the perspective taking phase

These results are confirmed by the t-test analysis on all participants, which shows that reaction time decreases significantly for the second experimental group in the perspective-taking phase compared to the baseline (p-level 0.036) – Figure 7A. This is not confirmed for the first experimental group, in which there is no-significant decrease in the mean reaction time (p level 0.308) – Figure 7B.

We also observe a lack of statistically significant differences between groups in the perspective taking phase, which points out a similar behavior in the two groups during the virtual embodiment.

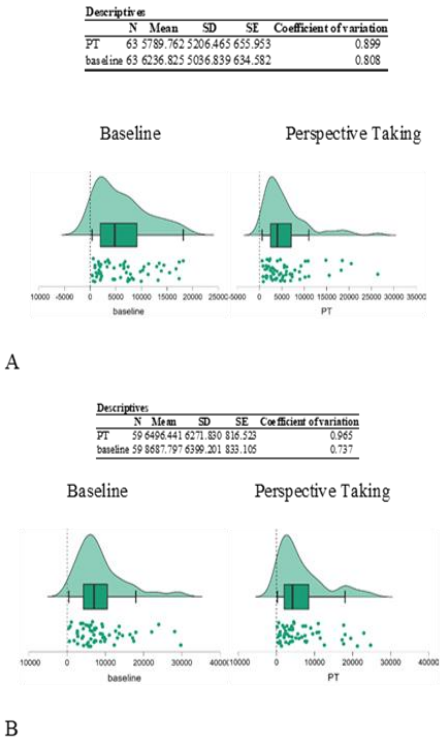


Figure 7: T-test analyses on the reaction time between baseline and the perspective taking phase show (A) a no-significant decrease in the mean of the RT in the first experimental group (p-level 0.308) and (B) a significant decrease in the mean of the RT in the second experimental group (0.036) in which the virtual embodiment precedes the verbal reflection

3.4. Electrodermal activity analysis

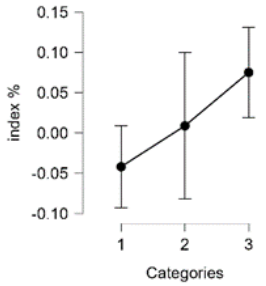
About the EDA, we calculated the difference index between the time of perspective taking and the baseline (time between the beginning and the interpretation phase) of the subjects. Then we converted it into a percentage.

We excluded outliers over 2SD from our analysis.

Our results show that there is a statistically significant difference (one-way ANOVA p-level 0.047) in the values of EDA (personal arousal index) between the three categories of subjects (1 non-empathic, 2 moderately empathic, 3 empathic) in the first experimental group, in which the perspective taking phase is anticipated by the reflection (interpretation-reflection loop).

T-test analysis between the perspective taking phase and the baseline, show a significant difference in category 3 (p-level 0.006). Here the EDA increases in the perspective taking phase (Figure 8).

On the other hand, there are no statistically significant differences regarding the EDA signals in the second experimental group in which the perspective taking is followed by the reflection (one-way ANOVA p-level 0.353). T-test analysis between the perspective taking phase and the baseline does not show significant differences. However, descriptive analysis shows that the average of EDA increases in the empathic people (category 3) compared to moderately (category 2) and non empathic (category 1) people.



Descriptives - index %

Categories	Mean	SD	N
1	-0.042	0.105	19
2	0.009	0.194	20
3	0.075	0.123	21

Figure 8: One-way ANOVA analysis on the arousal index shows that there is a significant difference in the experiment n.1 between the three categories (p-level 0.047) when the perspective taking follows a verbal and explicit reflection of other's feelings.

The personal arousal index, i.e. a physiological measure of emotional involvement, appears to be related to the subject's ability to empathize with others, in fact in both experiments it is higher in category 3 made up by people that totally change their feeling based on others interpretations.

The lack of significant differences in the second experiment, allow us to hypothesize that assuming a conscious perspective through an explicit reflection on other feelings before the virtual embodiment, increases the personal arousal of empathic people. However a larger sample is needed to better investigate the role of EDA in empathy.

3.5. Proteus Effect

Our results are in line with the recent literature on the Proteus Effect that considers avatars able to influence people's perceptions, behaviors, and attitudes in social interactions (Bian et al., 2015). In this sense, the proteus effect occurs when a strong bond is established between the user and the virtual

avatar (Kocur et al., 2019) and the virtual embodiment becomes able to influence the body ownership (Slater et al., 2010).

Pearson's correlations on our self-report questionnaires show that there is a negative correlation ($r = -0.350$ $p = 0.020$) between the subscale of the TAS-20 "Difficulty in identifying feelings" and the subscale of the PQ "Ability to examine", that is the ability to concentrate within the virtual environment. This result indicates that the greater the difficulty in identifying feelings, the less the ability to feel focused and involved in the virtual environment.

Furthermore, we recorded the cognitive and affective empathy (Davis, 1983) before and after the VR experience using ECQ and IRI questionnaires. In order to make a comparison, the data were first normalized and standardized on the basis of the mean and standard deviation of the sample itself. Results show no significant differences between questionnaires (repeated measures ANOVA).

Cognitive empathy is positively correlated to the PQ Sound subscale ($r= 0.375$; $p= 0.012$). This means that cognitive empathy increases as the truthfulness / realism of the verbal input increases. While affective empathy is positively correlated to the PQ Haptic subscale ($r= 0.339$; $p= 0.025$). This means that as haptic perception (the possibility of touching one's own body / avatar) in the virtual environment increases, affective empathy increases.

Furthermore, Proteus Effect is supported by the physiological index. We analyzed possible variations on the arousal index when subjects dress different bodies (i.e. nationality, age, gender). Our results show that there are no significant differences among categories in relation to the specific characters of the avatars (one-way ANOVA p-level: gender 0.109; age 0.147; nationality 0.237). It means that the emotional involvement is highly independent from the personal character of the avatars.

Discussion

In the current study, we explored the validity of immersive VR-driven methods to develop a sense of embodiment, and ultimately to increase social cohesion among users, with the help of a data-centric system, based on a communication between virtual reality and artificial intelligence systems (ongoing research).

To do this, we conducted a pilot study in order to understand if embodying a virtual avatar can foster the user's *Interpretation-Reflection Loop (IRL).*

For this purpose, we have built a virtual environment, in which avatars representative of specific people can interact with the experimental subjects, to discuss emotional and value-driven interpretations related to works of art.
We conducted two different experiments in order to understand if VR methodology is able to encourage empathy independently from the specific characters of the avatars and/or artworks.

We placed emphasis on the speech analysis in relation to the *IRL,* and in line with the recent literature (Osimo et al., 2015; Hamilton-Giachritsis et al., 2018; Kishore et al., 2022), our results show that VR methods can develop a sense of embodiment and maximize the human capacity to take another's point of view. We found that the percentage of people that change totally or partially their personal interpretation when they dress another body often exceeds the percentage of those who don't change it. For these analyses, we used (a) a manual speech-to-text methodology in order to compare the specific annotation of emotions and moral values before and after users' perspective taking; and (b) an automatic language inference system to detect emotions and moral values in the verbal speech of the users. Furthermore, related to virtual embodiment, our results show that dressing the avatar encourages the user to change their interpretation, even when in a preliminary reflection the user distances themselves from the avatar's interpretation. This result is in line with previous studies that show how the first perspective in an immersive VR leads to a strong feeling of embodiment towards an artificial body (Casula et al., 2022), as well as leading the user to be more empathic in relation to feeling like pain and pleasure (Fusaro et al., 2016).
These results entitle us to hypothesize that *IRL* through virtual embodiment involves a third element, which we classify as self-reflection, which increases empathic sharing between the subjects. VR-induced self-reflection might correspond to Kobriskii's (2017) *fast reflection*, a non-traditional type of reflection responsible for not consciously controlled and rapid human responses. In this sense, our analysis of the verbal reaction time confirms that having an experience in the body of other people leads to reflection guided by fast thinking, or System 1 (Kahneman et al. 1982; 2011), which could be

understood as non-traditional reflection (fast and self-referential) opposed to traditional verbal reflection attributable to slow thinking or System 2.

We also analyzed the index of emotional involvement, through the *EDA*. In accordance with other studies (Jakson et al.,2015), our results show an increase of electrodermal activity when empathic users dress another avatar's body, indicating a highly affective response. This result appears to be only significant when a user reflects verbally on another point of view before the virtual embodiment. However, a larger sample is needed to confirm this data.

Finally, our research confirms the importance of the Proteus effect (Van Loon et al., 2018) in the development of empathy inside a virtual world.

We found two important correlations related to (i) affective empathy as the ability to experience affective reactions to observed experiences (Davis, 1994), and (ii) cognitive empathy that involves perspective taking and theory of mind (Davis, 1994; Eslinger, 1998).

First, affective empathy increases with a higher haptic sensation, i.e., the possibility of touching one's virtual body and seeing it in the mirror with a specific synchronization between real and virtual movement facilitates the affective sharing of emotional states of other people.

Second, cognitive empathy increases with a higher auditory perception, i.e., the realism in the avatar's voice increases the ability to understand perspectives and intentions of others.

In addition, Proteus Effect is also confirmed by the *EDA.* In this sense, there are no significant variations of the emotional involvement due to the specific characters of the avatars. This means that virtual embodiment is not bound by the specific attributes of the avatars, e.g., age, gender and nationality. In line with other scholars (Slater, 2010; Banakou, 2012), we believe that VR can rapidly change the personal perception of the body, and probably reduce prejudice across different people (Yee and Bailison, 2006) as well as social and cultural differences (Christofi et al., 2017).

Future Developments

Based on the results of our pilot study, which are in line with the recent literature (Asher et al., 2018; Ahn et al., 2013;2016), the next phase in the

H2020 SPICE project involves the real-time modulation of the avatar profile based on the visitor's verbal responses. This will require communication between a user, a server (including multiple components), and a VR interface.
Our final application for museums, possibly extended to other domains, will be an intelligent system able to record personal interpretations of users, in order to place them in relation to people with different interpretations and/or different characteristics.
To do this, we are implementing a system capable of recording verbal interpretations on an external Linked Data hub, and analyzing and enriching them semantically (i.e. by performing zero-shot emotion detection, value detection, etc.). The system will also be able to use which can workflow management and speech analysis to guide an avatar engine, e.g., in choosing which avatar to present to a user (Figure 9).

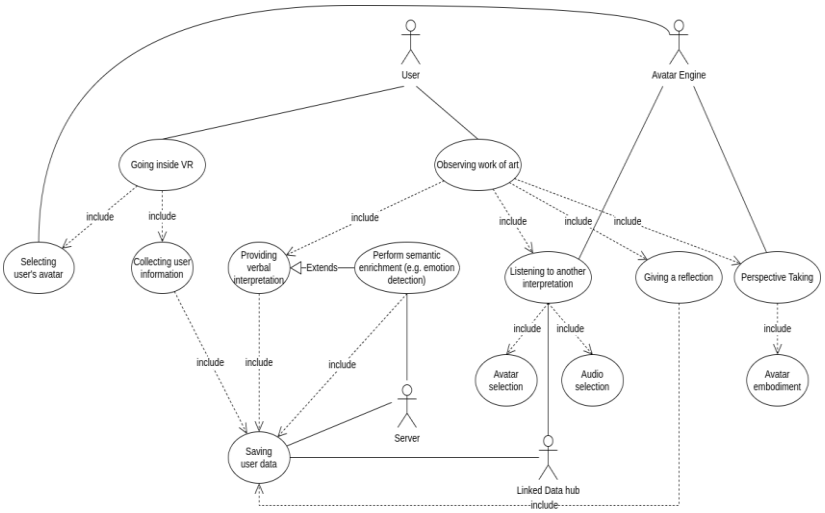


Figure 9: Use-case diagram of the real-time application

The user's dialogue will be also accompanied by an explicit choice of emotions linked to the work of art. In order to maximize the immersivity, the choice will be made by manipulating specific objects inside the virtual environment (i.e., the user can interact with tridimensional emoticons).
So far, we developed a total of 27 avatars, categorized by age, gender and nationality (Figure 10), and we are working on the real-time recording of verbal interpretations through the virtual interface.

Figure 10: 27 avatars representative of the population

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee (protocol code COSPECS_05_2022, date of approval: 12 April 2022).

Data Availability Statement: Data is available by contacting the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest

References

Ahn, S. J., Le, A. M. T., & Bailenson, J. (2013). The effect of embodied experiences on self-other merging, attitude, and helping behavior. *Media Psychology*, *16*(1), 7–38.

Ahn, S. J., Bostick, J., Ogle, E., Nowak, K. L., McGillicuddy, K. T., & Bailenson, J. N. (2016). Experiencing nature: Embodying animals in immersive virtual environments increases inclusion of nature in self and involvement with nature. *Journal of Computer-Mediated Communication*.

Asher, T., Ogle, E., Bailenson, J., & Herrera, F. F. (2018). Becoming homeless: a human experience. In *ACM SIGGRAPH 2018 virtual, augmented, and mixed reality* (pp. 1-1).

Asprino, L., Bulla, L., De Giorgis, S., Gangemi, A., Marinucci, L., Mongiovì, M. (2022). Uncovering Values: Detecting Latent Moral Content from Natural Language with Explainable and Non-Trained Methods. Proceedings of Deep Learning Inside Out (DeeLIO 2022): The 3rd Workshop on Knowledge Extraction and Integration for Deep Learning Architectures, pp. 33-41.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of autism and developmental disorders*, *34*(2), 163–175.

Barsalou, L. W. (2009). Simulation, situated conceptualization, and prediction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1521), 1281-1289.

Batchelder, L., Brosnan, M., & Ashwin, C. (2017). The development and validation of the empathy components questionnaire (ECQ). *PloS one*, *12*(1), e0169185.

Bian, Y., Han, L., Zhou, C., Chen, Y., & Gao, F. (2015). The proteus effect in virtual reality social environments: Influence of situation and shyness. *Acta Psychologica Sinica*, *47*(3), 363.

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological inquiry*, *13*(2), 103-124.

Boucsein W. Electrodermal activity. Berlin, Germany: Springer Science & Business Media, 2012.

Casula, E. P., Tieri, G., Rocchi, L., Pezzetta, R., Maiella, M., Pavone, E. F., ... & Koch, G. (2022). Feeling of Ownership over an Embodied Avatar's Hand Brings About Fast Changes of Fronto-Parietal Cortical Dynamics. *Journal of Neuroscience*, *42*(4), 692-701.

Christofi, M., & Michael-Grigoriou, D. (2017, October). Virtual reality for inducing empathy and reducing prejudice towards stigmatized groups: A survey. In *2017 23rd International Conference on Virtual System & Multimedia (VSMM)* (pp. 1-8). IEEE.

Daga, E., Asprino, L., Damiano, R., Daquino, M., Agudo, B.D., Gangemi, A., Kuflik, T., Lieto, A., Maguire, M., Marras, A.M. and Pandiani, D.M. (2022). Integrating citizen experiences in cultural heritage archives: requirements, state of the art, and challenges. *ACM Journal on Computing and Cultural Heritage (JOCCH)*, *15*(1), 1-35.

Davis, M.H., (1980). A multidimensional approach to individual differences in empathy. *Catalog of Selected Documents in Psychology*, 10 (MS. 2124) pp. 85-100.

Davis, M. H. (1983). Measuring individual differences in empathy: evidence for a multidimensional approach. *Journal of personality and social psychology*, *44*(1), 113.

Davis, M. H. 1994. Empathy, Madison, WI: Brown and Benchmark.

Ekman, P. (1999). Basic emotions. Handbook of cognition and emotion, 98(45-60), 16.

Fusaro, M., Tieri, G., & Aglioti, S. M. (2016). Seeing pain and pleasure on self and others: behavioral and psychophysiological reactivity in immersive virtual reality. *Journal of Neurophysiology*, *116*(6), 2656-2662.

Eslinger, P. J. 1998. Neurological and neuropsychological bases of empathy [Review]. European Journal of Neurology, 39: 193–9.

Gangemi, A., Presutti, V., Reforgiato Recupero, D., Nuzzolese, A. G., Draicchio, F., & Mongiovì, M. (2017). Semantic web machine reading with FRED. *Semantic Web*, *8*(6), 873-893.

Gangemi, A., Presutti, V. (2022). Formal Representation and Extraction of Perspectives. In P. Vossen at al. (eds.) *Creating a More Transparent Internet: The Perspective Web*.

Haidt, J. (2012). *The righteous mind: Why good people are divided by politics and religion*. Vintage.

Hamilton-Giachritsis, C., Banakou, D., Garcia Quiroga, M., Giachritsis, C., & Slater, M. (2018). Reducing risk and improving maternal perspective-taking and empathy using virtual embodiment. *Scientific reports*, *8*(1), 1-10.

Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: a meta-analytic review. PLoS medicine, 7(7), e1000316.

Holt-Lunstad J, Smith TB, Baker M. (2015). Loneliness and social isolation as risk factors for mortality: a meta-analytic review. Perspective Psychological Science J Assoc Psychol Sci, vol. **10**, pp. 227–37.

House JS, Landis KR, Umberson D (1988) Social relationships and health. Science 241: 540–545.

Jackson, P. L., Michon, P. E., Geslin, E., Carignan, M., & Beaudoin, D. (2015). EEVEE: The empathy-enhancing virtual evolving environment. *Frontiers in human neuroscience*, *9*, 112.

Kahneman, Daniel, Paul Slovic, e Amos Tversky, a c. di. (1982). Judgment under Uncertainty: Heuristics and Biases. Cambridge ; New York: Cambridge University Press. 106.

Kahneman, D (2011). Thinking, fast and slow. Macmillan.

Kishore, S., Spanlang, B., Iruretagoyena, G., Halan, S., Szostak, D., & Slater, M. (2022). A virtual reality embodiment technique to enhance helping behavior of police toward a victim of police racial aggression. *PRESENCE: Virtual and Augmented Reality*, *28*, 5-27.

Kobrinskii, B. (2017, December). Expert reflection in the process of diagnosis of diseases at the extraction of knowledge. In *IV International research conference" Information technologies in Science, Management, Social sphere and Medicine"(ITSMSSM 2017)* (pp. 321-323). Atlantis Press.

Kocur, M., Schwind, V. & Henze, N., (2019). Utilizzo dell'effetto Proteus per migliorare le interazioni utilizzando avatar a corpo intero nella realtà virtuale. Mensch und Computer 2019 - Workshopband. Bonn: Gesellschaft für Informatik eV. DOI: 10.18420/muc2019-ws-584

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive virtual environment technology as a basic research tool in psychology. *Behavior research methods, instruments, & computers*, *31*(4), 557-564.

Lucifora, C., Angelini, L., Meteier, Q., Vicario, C. M., Abou Khaled, O., Mugellini, E., & Grasso, G. M. (2021, February). Cyber-Therapy: The Use of Artificial Intelligence in Psychological Practice. In *International Conference on Intelligent Human Systems Integration* (pp. 127-132). Springer, Cham.

McPherson M, Smith-Lovin L (2006) Social Isolation in America: Changes in core discussion networks over two decades. Am Sociol Rev 71: 353–375.

Meuleman, B. & Rudrauf, D. (2018). Induction and profiling of strong multi-componential emotions in virtual reality. IEEE Transactions on Affective Computing.

Naito R, Leong DP, Bangdiwala SI, *et al* (2021). Impact of social isolation on mortality and morbidity in 20 high-income, middle-income and low-income countries in five continents. *BMJ Global Health* vol. **6:**e004124.

Nemiah JC, Sifneos PE (1970), Affect and fantasy in patients whit psychosomatic disorders. In OW Hill, Modern Trends in Psychosomatic Medicine. London: Butterworths.

Osimo, S. A., Pizarro, R., Spanlang, B. & Slater, M. (2015). Conversations between self and self as Sigmund Freud—A virtual body ownership paradigm for self counseling. *Sci. Rep.* **5**, 13899.

Pancani, L. (2020). La psicologia sociale nell'era digitale. In L. Andrighetto, & P. Riva (a cura di), *Psicologia sociale. Fondamenti teorici ed empirici* (pp. 281-304). Bologna : Il Mulino.

Putnam RD (2000) Bowling Alone: The collapse and revival of American community. New York, NY, US: Simon & Schuster.

Riva, P., Wirth, J. H., & Williams, K. D. (2011). The consequences of pain: The social and physical pain overlap on psychological responses. *European Journal of Social Psychology*, *41*(6), 681-687.

Riva, P., & Eck, J. (2016). The many faces of social exclusion. *Social exclusion: Psychological approaches to understanding and reducing its impact*, ix-xv.

Schutte, N.S., Stilinović, E.J. Facilitating empathy through virtual reality. *Motiv Emot* **41**, 708–712 (2017). https://doi.org/10.1007/s11031-017-9641-7

Slater, M., Spanlang, B., Sanchez-Vives, M. V., & Blanke, O. (2010). First person experience of body transfer in virtual reality. PloS one, 5(5), e10564.

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of communication*, *42*(4), 73-93.

Taylor, G. J., Bagby, M., & Parker, J. D. (1992). The Revised Toronto Alexithymia Scale: some reliability, validity, and normative data. *Psychotherapy and psychosomatics*, 57(1-2), 34-41.

Taylor, G. J., & Bagby, R. M. (2012). The alexithymia personality dimension.

Tomasello, M. (2014). The ultra- social animal. *European journal of social psychology*, *44*(3), 187-194.

Valtorta NK, Kanaan M, Gilbody S, *et al*. (2016). Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. Heart vol., 102, pp-1009–16.

Van Loon, A., Ballenson, J., Zaki, J., Bostick, J., Willer, R. (2018). Virtual Reality perspective-taking increases cognitive empathy foe specific others. *PlosOne*, 13(8), e0202442.

Ventura, S., Baños, R.M., Botella, C., Mohamudally, N.: Virtual and augmented reality: new frontiers for clinical psychology. In: State of the Art Virtual Reality and Augmented Reality Knowhow, pp. 99–118. InTech (2018).

Ventura, S., Badenes-Ribera, L., Herrero, R., Cebolla, A., Galiana, L., & Baños, R. (2020). Virtual reality as a medium to elicit empathy: a meta-analysis. *Cyberpsychology, Behavior, and Social Networking*, 23(10), 667-676.

Wesselmann, E. D., Grzybowski, M. R., Steakley-Freeman, D. M., DeSouza, E. R., Nezlek, J. B., & Williams, K. D. (2016). Social exclusion in everyday life. In *Social exclusion* (pp. 3-23). Springer, Cham.

Witmer, B.J., Jerome, C.J., & Singer, M.J. (2005). The factor structure of the Presence Questionnaire. *Presence*, 14(3) 298-312.

Yee, N., and Bailenson, J. N. (2006). "Walk A Mile in Digital Shoes : The Impact of Embodied Perspective-Taking on The Reduction of Negative Stereotyping in Immersive Virtual Environments," in *Proceedings of PRESENCE 2006: The 9th Annual International Workshop on Presence*, (Cleveland, OH) 1–9.