The Use of Storytelling in Virtual Reality for Studying Empathy: A Review

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***Abstract*—This review focuses on the use of storytelling in immersive Virtual Reality (VR) for studying empathy and seeks to examine the areas in which storytelling has been integrated in the selected manuscripts and how effective these interventions were. Findings indicate the rise of research in this area in the last decade. The most dominant narrative themes for inducing empathy were found to be narratives regarding mental and physical abuse victims, minorities and immigrants and people with a health syndrome, disease or disorder. Regarding the effect on empathy in comparison studies with other narrative methods, the VR method did not show a significant advantage over the other narrative methods. In the studies where only a VR method was used, the results were shown to be more promising. Moreover, this review also highlights the use of embodiment and perspective-taking, and the ways interaction was integrated in the studies.**

Keywords—virtual reality, immersive, empathy, storytelling, narrative

I. Introduction

The art of storytelling has been around since humans have been able to communicate [1] and emerged from basic human needs like recording history, entertainment, and sharing experiences with other people. Before humans invented and adopted written forms of communication, they used drawing (dating back to the stone age), poems, songs, and dance [2]. In the early days of storytelling, everyone could be considered a storyteller, from telling stories in family unions to singing songs and chants. As time went by, people became more skilled and were considered professionals, one example being the bards in Europe, who preserved history while entertaining with their music and poems.

Defining the term "storytelling" can be tough as scholars from different disciplines have their own definitions. However, it can be simply defined as the act of communicating to an audience, an event, or a story, which is a series of events [3]. Every story has a linear nature and flows from the beginning to the end. However, one story can be narrated in many different ways. For example, a story can be told as a narrative of flashbacks from the end to the beginning, or as a random series of events in any order. Both tell the same story, but the order of the events creates a completely different experience for the audience [4]. Nordquist [5] wrote about five elements that can define a narrative, namely a plot, a setting, characters, a conflict, and a theme. The plot is the series of events that occur in a story. The setting is the location where the events are happening in time and place. The characters are the people in the story who drive the plot and are either impacted by it or are passive bystanders who witness the unfolding events. The conflict is the problem that is sought to be resolved. The last one is the theme, which constitutes the story's framework and includes the moral of the story.

A. Virtual Reality and Immersive Storytelling

With rapid technological change and innovation, and the world becoming as digitized as ever, technology has an impact on the art form of storytelling as well [1]. Digital storytelling is defined as the idea of combining the art of telling stories with a mixture of digital graphics, text, recorded audio narration, video, and music [6], [7]. Digital stories, just like traditional storytelling, revolve around a chosen theme and often contain a particular viewpoint. Robin [8] categorized digital story types into (i) personal narratives: stories that contain details about incidents in a person's life, (ii) historical documentaries: stories that showcase events that happened in the past, and (iii) stories that inform the viewer of a particular concept. In the case of interactive mediums like video games, or immersive VR applications in the case of this review, a narrative's emotional impact could be different from all other more traditional types like books or movies. Qin, Rau, and Salvendy [9] describe the unique characteristics of game narratives as i) interactivity: unlike traditional forms of narrative, where the audience receives passively, in games the interaction is a form of participating actively in the narrative. Players can interact with the world and other characters and progress the story, and when the game involves player choice, then they can control what happens in the future, thus changing the narrative of the game with their actions. ii) Structure: Salen and Zimmerman [10] identified two structures for understanding the narrative components of a game: the embedded narrative, which provides the player with the context of the game, and the emergent narrative, which depends on the player's decisions and actions only.

As mentioned above, a story can be told or shown in different ways, which depends also on the medium used. An emerging narrative medium alongside written literature, cinema, and the theater is Virtual Reality (VR) [11]. In fully-immersive VR, a user is immersed in a 3D environment that is realized through computer-controlled display systems and so the user can interact with that 3D environment [12]. Immersion in VR refers to the technical capabilities of a system, such as a wide field-of-view vision, head tracking, high-resolution displays, and haptic feedback [13]. Especially in the case of VR systems such as Head Mount Displays (HMDs), the induced immersion levels are high enough as for

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the VR system to be considered as “fully-immersive” because the use of HMDs offers the impression that the VR user is completely enveloped by the virtual environment. Moreover, navigation into virtual environments with the use of HMDs is most commonly endocentrically experienced, which is the same way we experience navigation in a physical environment. On the contrary, non-immersive VR applications, with the most common example being desktop video-games, offer only a window to the virtual environment, which the VR user can interact with by proxy (i.e., virtual avatars). Therefore, the more technical capabilities are incorporated into a VR system, the higher immersion it offers, as the technical goal of VR is to replace the VR user’s real sense perception with computer-generated.

If sensory perception is successfully substituted, then the brain has no option but to recognize virtual reality as absolute reality, even though only on a subconscious level [13]. Therefore, it is possible to induce an illusion to the user of actually being located in the virtual environment. This is defined as Place Illusion (PI) and refers to the sense of “being there” in a virtual world, despite being aware that the virtual world is computer-generated [14]. VR is capable of eliciting a stronger sense of place illusion in a virtual world than traditional forms of media, and this is linked to stronger emotional responses [15]. Even more important to the concept of storytelling and empathy in VR is the Plausibility Illusion (Psi). Psi is relevant to the acting of the characters in the story and how likely it is for the VR user to perceive them as autonomous entities that seem to be sentient instead of artificial contraptions that seem to be programmed to act in specific ways [16] It is worth mentioning that Psi is irrelevant to photorealism or the quality of computer graphics, as it is apparent that cartoony representations in VR do not compromise Psi. A suspension of disbelief arises during surreal VR scenarios when the VR users endorse the fantastical elements of a virtual environment as “the valid reality for this world”. PI and Psi together are referred to as VR presence. Additionally, in VR it can be programmed so that a user's real body is substituted with a life-sized, spatially coincident and aligned virtual one, and the person can experience the events from the first-person perspective of that body. This process of embodiment in VR gives rise to the illusion of Body Ownership, whereby user perceives, under successful multisensory integration, a life-sized virtual body as their own [17]-[19]. Virtual Reality's affordances, namely its capacity for high levels of immersion, the illusions of presence and body ownership, and its level of interactivity, transform it into a medium that is distinctively different from any other media forms.

In fully-immersive VR, users can play a part in the story, through their actions, reactions, and behavior while interacting with the virtual world. It is argued that the power of simulated VR experiences derives from the felt intensity of being present and immersed in surreal settings and situations, which could result in a “roller-coaster” experience [13]. But real-life stories deriving from personal experiences of individuals can also be the subject of VR narratives and communicated as compellingly as any other VR narrative. VR has the capacity to mentally transport the user in a simulated location that might otherwise be hardly accessible, where stories of people from different communities and with different lifestyles and habits can unfold [20]. Even though every medium has the capacity to offer a narrative experience similar to VR, immersive VR is unique because of its aforementioned properties, namely immersion and the illusions of VR presence and body ownership.

B. Studying Empathy

Empathy refers to the ability of someone (empathizer) to understand and share the feelings of another individual (social target) [21], [22]. Perspective-taking on the other hand refers to one's cognitive capacity to perceive the world from another person’s viewpoint [23], [24]. A person could mentally transport into the mind of another in order to experience the “other” as the “self” and thus increase prosocial behavior. However, the experienced level of empathy always varies depending on the empathic capacity of the empathizer and how the empathizer feels for the given social target. Empathy is an ability that can traditionally be cultivated only through social interactions but the rise of the field of VR in the last decade offers new ways to cultivate empathy in people. In VR, unique experiences of prosocial value can be created and viewed from multiple perspectives engaging the user into active roleplay. Individuals who seek to enrich their empathic capacity no longer have to rely solely on in-vivo social encounters or their imagination, which can be laden with erroneous preconceptions and biases regarding specific social targets. Well-informed and impartial experiences of prosocial value that delineate what it is like being somebody else can be created and disseminated through the VR platform. With the use of VR, we can have the opportunity to experience the life of another person and understand another point of view [23]. Narratives allow us to understand the context of another person’s affective and cognitive situation, and also how an experience is personally meaningful for them. When a person’s affective state is communicated through language, we can construct visual or auditory images of their experiences [24]. However, when those images are provided in VR, narrative engagement is enhanced and can tap into deeper context for the narrator’s affective states.

Well known companies and institutions have been making VR 360° degrees films from charities like the International Rescue Committee (IRC) [1] and Amnesty International [2], immersing people in the world of a refugee camp in Lebanon and Syria. Moreover, the United Nations run a program called "United Nations Virtual Reality (UNVR)", which uses the power of immersive storytelling to inspire viewers toward increased empathy, action and positive social change. Additionally, companies like HTC and Meta have programs using VR technologies in order to promote [3]y and social welfare, called "VR for Impact" [4] and "VR for Good" [5] respectively.

This review goes beyond 360° videos and seeks to find the approaches that researchers take in the direction of inducing empathy through their custom immersive storytelling VR applications. The questions to be answered in this review are the following; i) In which areas has storytelling been integrated into immersive VR applications in studies with an aim to study empathy? The review will categorize the selected studies into Robin’s types of digital narratives as mentioned

[1] https://www.amnesty.org/en/

[2] https://unvr.sdgactioncampaign.org

[3] https://www.vive.com/us/newsroom/2017-01-20/

[5] https://www.oculus.com/vr-for-good/

above [8] (personal narratives, historical documentaries, and stories that inform about a concept). It will also seek to find more details about the VR devices used and whether perspective-taking and embodiment to a virtual avatar were incorporated. The second question to be answered in this review is ii) How effective are immersive VR interventions that have a storytelling component for achieving a change in empathy? We investigate quantitative studies with published results and report on how the VR methods compare to non-VR ones, as reported in these studies.

II. RESEARCH METHODOLOGY

The chosen approach for addressing the research questions of this study is a systematic literature review. This type of review was chosen because it has as its aim to identify, evaluate, and summarize the findings of all relevant studies over a topic, thereby making available evidence more accessible to researchers [25]. This method also is used when trying to examine "the feasibility, appropriateness, meaningfulness or effectiveness" of the methods used [26]. In this section, we explain the procedure we followed in order to retrieve the selected manuscripts. Before that procedure, a number of inclusion and exclusion criteria were set in order to specify the characteristics of the manuscripts that are qualified for this review. Consensus between two of the authors of the review was ensured in every step of the procedure.

A. Inclusion Criteria

The inclusion criteria were: i) Manuscripts published in English. ii) Manuscripts on the topic of VR that include a storytelling/narrative component. Although not always explicitly referred to as "narratives" or "storytelling" in the manuscripts themselves, we attempted to manually identify them in each manuscript, as VR experiences where the user is guided through a series of events unfolding as a storyline around them in the virtual world. iii) Manuscripts that studied empathy. iii) Peer-reviewed academic manuscripts (research articles, and quantitative studies).

B. Exclusion Criteria

The exclusion criteria were: i) Academic manuscripts published before 2010. ii) Manuscripts using exclusively non-immersive VR and other non-VR approaches. iii) Manuscripts using exclusively 360° videos. iv) Using commercially available VR applications. For the present review, it is considered important to maintain a high level of homogeneity among studies, for the studies to be easily comparable, as comparisons between studies correspond to the questions sought to be answered. Specifically, comparisons could help in identifying the most common research methods chosen by creating custom applications, whether they include embodiment and perspective-taking, or how interaction is integrated in these applications, and ultimately how effective they are in inducing empathy. It is argued that commercial storytelling applications are primarily geared towards creating an engaging and marketable story for a specific target group while aspects of evoking empathy for real-life social targets come second by default. Therefore, non-commercial applications (minimum viable products for research projects) that are specifically created for studying empathy and commercial applications (finished products with multiple components irrelevant to the subject) that were created to induce empathy as a secondary function could be too different for allowing a productive comparison.

C. Search Methods and Outcomes

A search was conducted in the following electronic databases, which were regarded as possible venues for VR research: IEEExplore (64), ACM Digital Library (72), Eurographics Digital Library (1), Scopus (132), WebOfScience (111), Springer Link (115), ScienceDirect (41), PubMed (125). The search keywords, by looking into the authors' keywords and abstract, were "virtual reality" AND "empathy". In the stage of the manuscript retrieval, the usage of the keywords "storytelling" and "narrative" was also considered in the beginning. However, in the first few searching sessions, it was clear that these words were bringing a lot of irrelevant publications in the search results, as these are terms used in many other research areas. The database search yielded 661 manuscripts in total that were published from 2010 to 2022.

D. Data Extraction

The screening and selection of the manuscripts were carried out on www.rayyan.ai, which is a web tool developed to help researchers carry out collaborative systematic reviews [27]. After all the sources were uploaded to Rayyan, the 661 publications were manually categorized as duplicates (292), irrelevant (427), and relevant (62), by their title and abstract.

E. Quality appraisal

After the data collection stage was completed, a quality appraisal of the papers deemed as relevant was conducted. After a thorough examination of each one of the 62 relevant manuscripts, by using the inclusion and exclusion criteria defined by the authors for this review, it became apparent that the relevance of 42 manuscripts should be reconsidered, and they were removed as they did not fit the inclusion criteria. The final number of manuscripts was 20 (Fig. 1).

F. Data synthesis

The extracted data from the 20 included manuscripts were grouped by the type of digital story used. In addition, we examined and presented whether interactivity, perspective-taking, or embodiment was incorporated in the VR applications. In the results, we present an overview of the studies, the VR headsets and game engines used, the grouping of the manuscripts, and lastly, we report on the effectiveness of immersive storytelling in these VR manuscripts and suggest future directions.

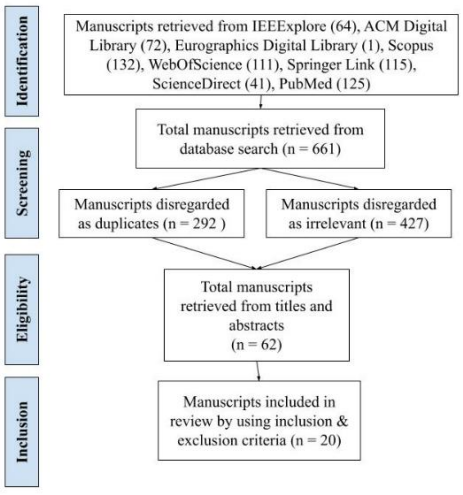

Fig. 1. Flow diagram of the manuscript retrieval process according to the PRISMA statement methodology.

III. RESULTS

An overview of the 20 selected manuscripts indicates that the use of immersive storytelling in VR for inducing empathy has rapidly grown in the last 6 years, as all of the selected papers were published since 2016, with a 25% of them (n=5) in 2018 and an equal 30% (n=6) in both 2020 and 2021.

Regarding the VR head-mounted displays used in these studies, most of these used the HTC Vive (n=10). Oculus devices were also used (n=8) as well as the nVisor SX III (n=1). The game engines used to develop the VR applications mentioned in these manuscripts were Unity (n=7), the Unreal Engine 4 (n=1), and NeoAxis (n=1).

A. Interaction

As mentioned above [9], one of the unique characteristics of game narratives, and in this case immersive VR applications, is interactivity, which was indicated as one of the main factors to be examined in this review. The results are somehow divided, as in 55% of the selected manuscripts (n=11), the users cannot interact in any way inside the VR application with objects or virtual humans, and are simply observers of the events occurring around them.

The forms of interaction included in the studies mostly included interaction with objects and navigation within the virtual environment. In [28], [29], users were able to explore their immediate surroundings and interact with objects in their view. In [30] and [31], users could interact with objects in rooms by maintaining their gaze for a few seconds at them. In [32] and [33] the users had tasks to complete in a virtual food court and in the final scene they interacted and had a conflict with a virtual avatar. In [34] participants could select and pick up objects in a house of an evacuee in the 2011 Fukushima Daiichi nuclear disaster and could draft a report in the end. Finally, in [35], participants could act and move in the virtual environment by pressing four buttons on two MRI-compatible response pads.

B. Types of digital narrative

Efforts in studying empathy are not limited to studies that have as a goal to induce empathy for stigmatized society groups. In this review, we attempt to categorize the selected manuscripts by the type of digital story used as mentioned in [8]. These categories are namely; (i) personal narratives which are stories that contain details about incidents in a person's life, (ii) historical documentaries, which are stories that showcase events that happened in the past, and (iii) stories that inform the viewer on a particular concept through an experiential approach (educational).

On some occasions, two types of themes were overlapping for some of the manuscripts. In Mado et al.'s study [36] two different VR applications were used for the two conditions. One of the applications was meant to raise awareness for ocean acidification and the other one was about a person who became homeless. In [30] participants were embodied in individuals with major depressive disorder and Asperger syndrome [31] while at the same time learning about those concepts, which makes both studies befitting the theme of personal narrative and the type of educational digital narratives. Kors's [34] study is also one example of a study for which two categories were assigned. In this study, participants were immersed in a VR game that was designed and developed to foster empathy toward evacuees from the 2011 Fukushima Daiichi nuclear disaster. Participants take the perspective of a reporter tasked to interview an evacuee and pick up objects that trigger vignettes that narrate stories about this disaster, thus this manuscript used a personal narrative and a historical documentation type of narrative. Below follows an overview of the types of narratives present in the rest of the selected studies.

(i) Personal narratives: 65% of the manuscripts included solely a personal narrative type (n=13) in their VR application and 85% included at least a personal narrative (n=17). We attempted to further group the studies involving a personal narrative into subthemes. The most dominant subthemes that occurred from our examination of the narratives in the selected manuscripts, were (a) narratives regarding mental and physical abuse victims, (b) narratives about individuals who belong to stigmatized social groups and the discrimination they face and (c) narratives of people with some kind of syndrome, disease or disorder. Narratives regarding mental and physical abuse victims included studies about bullying in a school [37], teacher training about multiculturalism and verbal bullying [38] and, victims of domestic violence between intimate partners, with the husband as the abuser and the wife as the VR avatar[39], and the relationship between mother and child, with the mother as the supporter or the abuser and the child as the VR avatar [40]. Narratives about individuals that belong to stigmatized social groups and the discrimination they face, included stories about black people [41], immigrants and minorities [32], [33], and events from the life of a person who became homeless [29] and a drug user [42]. Stories of people having a special condition included studies regarding patients with chronic pain [43] and dementia [44]. A personal VR narrative that was deemed as incompatible with the established subthemes is the one about embodying a boy getting a dental visit for a check-up [45]. The study pertained to studying empathy amongst dental students.

(ii) Historical documentaries; In two studies [28], [46], the narrative shown to the participants, was a recreation of significant events from the Kokoda campaign in Australia. It was the location for a significant military campaign between Australian and Japanese soldiers in World War Two.

(iii) Educational; The study described in Blythe et al. [42] included an environmental theme in the narrative. Their aim was to test the extent to which optimistic or pessimistic storylines influence empathy. The "optimistic" scenario depicted a world focused on environmental sustainability. The "pessimistic" scenario depicted a world dominated by resurgent nationalism, regional conflicts, and environmental degradation.

C. VR embodiment and Perspective-Taking

By utilizing VR's unique affordances, users when immersed in a virtual world get the opportunity to experience the life of another person from a first-person perspective and understand their point of view [24]. This experience can be even more enhanced if users can virtually embody that person as well in the virtual world [13]. The vast majority (75%) of the selected manuscripts (n=14) wanted to include this enhanced experience in their VR applications, as they included both perspective-taking and embodiment. More specifically, only 2 out of 17 manuscripts that involved a personal narrative [37], [44], did not involve either perspective-taking or embodiment. Some noticeable cases in which real-time full-body tracking was integrated into the VR applications is [40] in which participants experienced being in

the virtual body of a kid in a first-person perspective (1PP) with the use of the Optitrack full-body motion capture suit. In [42], participants embodied a person who became a drug user by wearing the Xsens Awinda full-body motion capture suit and the ManusVR Xsens edition gloves for finger tracking. Finally, in [39], participants embodied a virtual female undergoing violent behavior. In this case, the Microsoft Kinect was used for full-body tracking of the participants.

D. Effect on empathy

As mentioned above, this review focuses on the use of storytelling in immersive VR for studying empathy. One of the factors under examination is whether the immersive VR methods are found to be significantly more effective in inducing empathy, in comparison to other more traditional or digital methods and also in studies where there were not any comparisons made.

1) Comparison with other non-VR narrative methods

First, we present the results from the comparison studies (n=8). In only 37.5% (n=3) of these studies, the immersive VR method was shown to be significantly more successful at inducing empathy than the ones it was compared to. In [28], [46] the developed Kokoda VR application was compared to its 360° equivalent. In both cases, participants in the VR group had a significant increase in their empathy version over 360° video. Moreover, in one of the two studies presented in [29], participants in the VR perspective-taking task condition reported feeling significantly more empathetic for the homeless man presented in the narrative than participants in the traditional narrative perspective-taking condition immediately following the intervention. The immersive VR versions of applications were sometimes compared to their Desktop equivalents with similar effects on empathy [29], [42] as well as compared with more traditional narrative methods like text, with similar results, not in favor of the immersive VR applications [29], [30].

2) VR only

Here we present the results from the studies in which only immersive VR methods were used in the experimental group(s) (n=12). From those, 8 examined the efficacy of VR in evoking empathy. Studies presented in this subsection were focusing solely on the content of the VR application and not the technology used. In some studies, all participants experienced the same scenario [34], [35], [39]-[41], [43]-[45], or comparisons were made with different viewing perspectives (first vs third) [33], or they viewed different immersive VR applications [36], or the same with some differences like different endings [31], [46].

In the case of studies in which all participants experienced the exact same VR application, results were found to be promising, since most of them showed a significant change in empathy scores before and after the participant's exposure [34], [39]-[41], [44], [45]. In only two cases no significant change in empathy before and after was found [35], [43].

A happy versus sad narrative (or in the case of [31] a sad ending) was compared. The results were contrasting, as in [31], the experimental group, that experienced the positive ending, a very significant correlation between dispositional empathy and affective arousal was shown. In the case of [47] the increase in empathy was significantly larger for the pessimistic scenario. No significant effect on empathy was shown when comparing embodying ingroup-outgroup members [32] or first versus third-person perspective [33] or showing different scenarios [36]. Table 1 highlights the reported results.

Table I. Summary Table of Results

Characteristic	**VR applications for studying empathy**		
	Category/ Theme	***Subcategory/Subtheme***	***N***
Interaction	High	-	9
	Low	-	11
Narratives	Personal	Victim of abuse	17
		Out-group discrimination	
		Having a special condition	
		Other	
	Historical	-	3
	Educational	-	4
VR affordances	Full-body tracking	-	3
	Perspective-taking	-	14
VR efficacy in inducing empathy	Comparison studies	Significantly high	3
		Non-significant	5
	VR only studies	Significantly high	6
		Non-significant	2

IV. DISCUSSION AND CONCLUSIONS

Telling a story through an interactive medium like immersive VR brings new challenges but more importantly, it can also bring potential [48] for creating meaningful experiences, for which it is not possible or it is difficult to experience otherwise.

Immersive VR has been a powerful tool in the hands of social psychologists to study human behavior in general, and it can be used to simulate all kinds of scenarios. What makes VR unique in this sense, is that we can replicate a developed VR scenario in the safety of a laboratory, as many times as we want, make tweaks on the go, and the researchers have the ultimate control.

More specifically, immersive VR can be a very useful and powerful tool in the research of empathy, because it can transfer you to another world and change your sense of self. VR has been mentioned and called by many as the “ultimate empathy machine” [21], thus the rise of the number of studies conducted for this cause in the last decade. VR and its transformative power allow people to view the perspective and lives of other people or transfer them into imaginary places and scenarios, where they can learn and momentarily take the role of another person.

Results showed that the most dominant narrative themes for inducing empathy were narratives regarding the hardships of people. The themes that were more dominant, were narratives about mental and physical abuse victims, narratives in which participants were able to embody and take the perspective of the homeless, drug users, black people and immigrants, and experience in VR, the discrimination they face and also stories of people with a health syndrome, disease, or disorder like chronic pain, dementia, Asperger syndrome and major depression disorder.

A comparison of the effectiveness of these methods with other narrative methods showed that in only 3 cases the immersive VR method was significantly more successful at inducing empathy. This lines up with previous research [49] which revealed that immersive systems can elicit higher levels of negative emotions than desktop platforms. When solely an immersive VR method was used, results were promising, since the vast majority of them showed a significant increase in empathy scores before and after the participant's exposure.

Most of these studies that included personal narratives, utilized VR's affordances like perspective-taking and embodiment. A vast majority of the selected manuscripts included both. It was shown that from a social-psychological perspective, participants who experience a virtual body may change their attitudes and behavior to correspond to what they thought would be expected from a person with that type of body. This is a phenomenon that they named as "Proteus effect" [50].

Empathy seems to be hardly affected when comparing the effect of different scenarios in which participants embody ingroup-outgroup members or abuser-victim-neutral perspectives. The number of VR studies regarding perspective-taking and empathy were too scarce to allow drawing any accurate conclusions. Even so, it is worth noting the findings of a study [51], which compared the impact of an immersive virtual scene of intimate partner violence, from the victim's perspective (first person), and a neutral observer's perspective (third person). It was shown that the first-person perspective helped participants to experience the scene to a personal level, and it generated a sensation of fear, helplessness, and vulnerability, and tended to induce greater behavioral and physiological reactions.

The studies included in this review had as a goal, in general, to induce some emotional impact on participants. Emotional impact is measured through the difference between affective states evoked by participants before and after their exposure to an emotive experience [31]. The affective states of a person are characterized by valence and arousal. Valence is the measure for the positivity or the negativity of an experience [52]. Valence is influenced by people's tendency to focus on the pleasant or unpleasant aspects of an experience. Arousal, on the other hand, is about the interpretation of affective experiences in terms of intensity [53]. Two studies in this review tried to examine whether a positive or negative scenario influences empathy. However, valence values and their respective effect on empathy seem contradictory between these two studies, which are insufficient for drawing any conclusions.

Regarding empathy, and how it was measured, all empathy measures in the selected studies were based on self-reported questionnaires, which are oftentimes subject to social desirability bias [54], which could explain some of the results. This bias is a type of response bias that explains the tendency of participants to respond to questions in a manner that will be viewed favorably by the researchers. This occurs in the case where research is conducted solely with the use of self-reports. This bias ultimately tends to interfere with the interpretation of average tendencies as well as individual differences in participants.

A review regarding the available tools to measure empathy showed that the most popular ones are self-reports [55]. As noted by the authors of that review, that result was not unexpected, given that self-report measures are easy to use and faster to analyze. The same review also highlights other methods of measuring empathy. One example is the fMRI activation paradigm [55]. It is used to expose activation areas related to empathy processing. The second example mentioned is electromyography (EMG). It is used to capture the electrical activity of facial muscles. It is argued that their reaction is related to emotional expression [56]. A final example is electroencephalography (EEG) activity that could potentially help detect empathy while processing social threat-related information.

Although interaction has been found to increase empathy [57], the forms of interaction included in these studies mostly included interaction only with objects and navigation of the virtual environment, rather than interaction with other avatars.

The findings of this review indicate the rise of interest in research regarding immersive storytelling use in VR studies for studying empathy, in the last decade, and more specifically in the last 6 years, in which all the selected papers in this review were released. With the biggest VR companies like the Oculus from Meta and VIVE releasing new, better and more affordable VR HMD's yearly, VR could possibly soon become a part of more research labs and even households.

However, this review illustrated that there is still much to be discovered, as results were not unanimous in favor of immersive VR methods. Interactivity with avatars is one of the factors that researchers need to expand upon. With advances in the fields of AI and virtual avatars, developers can create conversational agents that could enhance narratives. Multiplayer experiences can also be explored, where users can modify and create their own narratives. One of Meta's goals with its metaverse[6] is to evolve social connections, so that people can defy distance and connect with others and the world around them. This can be utilized in VR experiences for the induction of empathy as well.

Furthermore, with the addition of haptic devices, such as the most widely used haptic gloves, users can also feel haptic sensation to their palms and fingertips, obtained through virtual interaction, by providing distributed force and tactile feedback to those areas. Haptic devices allow users to touch and manipulate virtual objects in a direct and intuitive way [59]. Full-body wearable technologies also exist with sensor inputs and outputs but are usually more expensive and less comfortable to wear and to set up.

These VR experiences could be further enhanced with the inclusion of embodiment, where the user can experience being in the body of a virtual person. Nowadays, affordable motion capture methods are available, with the use of controllers and a few trackers. The virtual body can either resemble its host (user) or not, depending on the needs of the VR experience and narrative.

The exploration of the narratives' context and endings could also be the focus of future studies. Whether it is more effective to have a positive or a negative narrative (or ending) for the induction of empathy was not conclusive in this review. Users can also play a part in the narrative and be given the ability to make decisions. Meaningful choices can help users

[6] https://about.facebook.com/meta/

to communicate with the narrative's characters on a personal level and empathize with them [60]. Moreover, if users truly feel like they are embodying the social target of empathy, then they can feel the need to ensure that their actions will lead to a consistent characterization of them [61]. The goal should be for the user to step in the shoes of that person, so that they make choices not as their real selves but as the person they embody.

This can be tricky to achieve though, as Belman and Flanagan [62] noted that people are more likely to empathize with a character only when they make an intentional effort to do so. When given a choice, and when people know that the events that occur in the virtual world are "not real", then they might be more inclined to make choices they would not normally do in real life or intentionally make bad choices just to explore the impact of the consequences on the story and the limitations of the system. More research on the aspect of Psi in VR needs to be carried out in order to make substantial steps in the area by finding out how to best design plausible scenarios and interaction paradigms that evoke empathy without alienating the VR user [16].

Lastly, although the selected studies included narratives about many groups of people that are usually stigmatized by society, including black people, minorities and immigrants, there was a noticeable lack of narratives about LGBTI people. According to the Universal Declaration of Human Rights, discrimination against LGBTI people undermines the human rights principles [63]. However, in 70 countries, discriminatory laws still exist, and in at least 5 countries these people are faced with the death penalty. Countries can strengthen their human rights protection for these people, but VR can play a role too, with meaningful VR narratives of LGBTI people as well.

This review has some limitations that need to be addressed. Firstly, it is unlikely that all relevant studies were identified, despite the best efforts of the authors. This is one of the most standard limitations of reviews and the authors tried to mitigate this limitation by thoroughly searching 8 of the most popular libraries that were most likely to contain relevant to the subject papers. Secondly, although not exactly a limitation, this review was shaped by papers which were retrieved by a pre-defined set of eligibility criteria. As the authors attempted to accumulate a homogenous and thus comparable (i,e., in terms of efficacy measures) sum of studies, it is possible that noteworthy aspects relevant to empathy, storytelling, and VR were excluded during the manuscript retrieval process.

In conclusion, interest in the field of immersive storytelling in VR studies for the study of empathy is rising every year. Storytelling has been around since humans have been able to communicate. Then, storytelling was used to record history, tell stories for entertainment, to interpret social or cosmological phenomena, to pass down cultural legacy, and to recite poems. Storytelling can be used for instigating prosocial behavior by inducing empathy to people. VR has become a new narrative medium with its unique affordances like immersion, interactivity, embodiment and perspective-taking. With all these ongoing technological advancements in the field of VR, the equipment is finally being more affordable, powerful, portable and accessible to researchers and the public than ever. The results of this review will hopefully guide and direct future studies for this cause and open up even more opportunities for VR developers and researchers to create meaningful experiences that can induce empathy.

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