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Insights into the Predictors of Empathy in Virtual Reality Environments

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Abstract: The effectiveness of virtual reality (VR) in eliciting empathy lies in the fact that VR offers possibilities for situating people in a specific context and in the shoes of others. Previous research has investigated the benefits of VR in eliciting empathy and has compared VR with other technologies. However, there is a lack of research on the predictors of empathy in VR experiences. To fill this gap in the literature, this study aimed to identify the predictors of empathy when VR is used as a medium to elicit empathy. A structural model based on hypotheses was validated using partial least squares–structural equation modeling (PLS-SEM) with data from the interaction of 100 participants in a tailor-made VR experience developed to create empathy toward migration. The results show that our model explains 44.8% of the variance in emotional empathy as a result of the positive influence of compassion and attitudes toward migrants. Moreover, the model explains 36.8% of the variance in cognitive empathy as a result of the positive influence of engagement, attitudes toward migrants, compassion, and immersion.

Keywords: emotional empathy; cognitive empathy; virtual reality; predictor; migration

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Citation: Bacca-Acosta, J.; Avila-Garzon, C.; Sierra-Puentes, M. Insights into the Predictors of Empathy in Virtual Reality Environments. *Information* **2023**, *14*, 465. https://doi.org/10.3390/info14080465

Academic Editor: Gerrit Meixner

Received: 28 June 2023
Revised: 31 July 2023
Accepted: 14 August 2023
Published: 18 August 2023

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1. Introduction

Empathy is a construct that represents an "emotional response to other's distress, suffering or pain" [1]. The origin of the term empathy dates back to 1873, when the philosopher Robert Vischer used the German term "Einfühlung" (feeling into) as an expression in art appreciation. Later, in 1909, Edward Bradford translated the German expression into the English term "empathy" [2]. Empathy is usually divided into emotional empathy and cognitive empathy. On the one hand, emotional empathy means that a person is emotionally moved by a situation. On the other hand, cognitive empathy involves understanding the thoughts and emotions of others, and this has been regarded as perspective taking. In short, the difference between the two concepts is that perspective taking (cognitive empathy) involves the experience of how the other person feels or views a particular situation, while emotional empathy is related to being emotionally moved by a situation that another person experiences.

Virtual reality (VR) is a medium for immersion in a virtual environment generated by a computer. VR is a collection of hardware that includes computers, head-mounted displays (HMDs), and sensors, and it allows one to experience telepresence [3]. Virtual reality (VR) has been used as a technology for perspective taking, and some VR applications have been used for developing empathy in different contexts [4]. Recent research has shown that perspective-taking experiences might have transferable effects on real life [5]. The effectiveness of VR for perspective taking lies in the fact that VR is useful for situating a person in a specific focused context, which reduces the cognitive load needed to imagine the situation, and then allowing them to understand the views and feelings of others [6]. However, there is a lack of research on the factors that influence empathy when VR is used

as a medium to elicit empathy [7]. Recent research suggests that more studies need to be conducted to understand the intricacies of some factors that contribute to eliciting empathy in a VR experience, such as presence, immersion, and engagement [8]. Moreover, recent research on the effect of VR in eliciting empathy has shown mixed results [9]. There is also a lack of research on how empathy should be considered in strategies for communication about migration [10].

This study differs from others in the literature in that previous research has focused on investigating how user experience factors might influence empathy change. For instance, Barbot and Kaufman [11] investigated how user experience (UX) factors predict empathy change in VR experiences. Cummings et al. [9] investigated how some factors of presence, such as self-location, co-presence, and social realism, mediate the effect of immersion on empathy in VR. In the same vein, Cohen et al. [7] found that social presence mediates the relationship between the use of VR and empathic care. Similarly, Lee and Li [8] found that presence is positively correlated with empathy. However, in order to advance the research in the field, in this study, we investigate how other factors such as engagement, compassion, attitudes, and immersion (associated with a VR experience) might predict empathy. This study is in line with the call for more research on the features of VR that might be useful to facilitate empathy [6]. In this context, the main research question that drives this study is as follows: what are the predictors of emotional and cognitive empathy in VR environments?

The remainder of this paper is organized as follows: Section 2 describes the related work. Section 3 describes the hypothesis development. Section 4 describes the methodology, participants, research design, and details of the educational intervention. Section 5 describes the results of the hypothesis testing, and, in Section 6, the results are discussed. The limitations of this study are presented in Section 7. Finally, conclusions and future work are presented in Section 8.

2. Related Work

2.1. Virtual Reality and Empathy

The research on VR and empathy has focused on different aspects. One of these aspects has been the investigation of whether VR is more effective in eliciting empathy than other technologies. In this line of research, for instance, Rodríguez and Rozo [12] found that a videogame is more effective in eliciting empathy toward migration processes than a documentary on the same topic. Cohen et al. [7] found that 360° videos are more effective in creating empathy than 2D videos. However, other researchers have not found differences in empathy change and the sense of presence between 360° videos in VR and traditional videos [13]. Sundar et al. [14] found that a narrative in a 360° video is more effective in terms of the sense of presence, credibility, and feelings of empathy than reading the story in text with images.

Recent research has investigated some of the factors of VR experiences that are effective in creating empathy. For instance, Cohen et al. [7] found that the sense of social presence is a factor that mediates the benefits of 360° videos presented in VR and the levels of empathy. Cummings et al. [9] found that some dimensions of presence, such as self-location, co-presence, and social realism, mediate the effect of immersion on empathy in VR. In particular, co-presence influences cognitive empathy, while self-location and co-presence influence associative empathy. Similarly, Lee and Li [8] found that presence mediates the relationship between immersion and empathy in VR environments. However, further research is needed to identify how some aspects such as immersion and presence lead to increased empathy [8]. Overall, previous research has focused on presence and immersion and their effects on empathy. However, other factors such as attitudes and compassion deserve the attention of researchers to uncover the aspects of a VR experience that affect empathy.

2.2. Virtual Reality and Migration

To investigate the predictors of empathy, in this study, we focused on empathy for migrants using immersive VR (a higher level of immersion) because it is a relatively underexplored field. Immersive VR refers to the use of a head-mounted display (HMD), in which the user is completely immersed in a computer-generated environment and can move in six degrees of freedom (6 DoFs) in the VR environment. In this regard, this study differs from other approaches that have been used to investigate the effect of VR on empathy, such as 360° videos (in which the user is a passive agent), and some examples of this approach can be seen in Hollick et al. [15] and Schutte and Stilinović [16]. These two studies are described later in this section. Another approach that can be used is non-immersive VR (using a traditional computer monitor showing a VR environment) in which the level of immersion experienced by the user is very limited. However, to the best of our knowledge, no studies have been conducted using the latter approach. Although some studies have been conducted, the field is still in its infancy. In this section, we describe previous studies in the field of VR that have attempted to create empathy for migrants.

In previous studies, 360° videos were used because they could provide higher levels of empathy, as they achieved higher levels of presence [15]. Among these research papers, the study by Jones and Sommer [17] can be mentioned, as it compared a virtual reality immigration environment at the US–Mexico border to reading an article on the same topic. However, the results did not show significant differences between the use of virtual reality and a printed text on the subject.

Schutte and Stilinović [16] concluded that a 360° video showing the documentary "Clouds Over Sidra" through virtual reality generated higher levels of empathy than a traditional video (different from 360°). Similarly, Martingano et al. [18] concluded that 360° virtual reality videos had a positive short-term effect on emotional empathy when compared to control conditions, which consisted of reading stories similar to those shown in the 360° video only through text. However, the authors did not find a significant effect on cognitive empathy. Gitau et al. [19] developed a virtual reality environment called EmbodiMap, where a group of refugees can register their feelings and emotions in a creative and innovative way. Documentaries have also been used as a medium to create empathy for migrants, with promising results [20].

Although previous research has been conducted on creating empathy for migrants using VR, the factors that predict emotional and cognitive empathy when using VR still remain underexplored. To fill this gap in the literature, in this paper, we investigate some of the factors that might predict emotional and cognitive empathy when using VR environments to create empathy for migrants. The next section is dedicated to defining a model based on the hypotheses of some factors that, according to the literature, might influence empathy in VR environments.

3. Hypothesis Development

3.1. Engagement

Engagement has been widely investigated in psychology, education, and computer science, but there is a lack of consensus on one concrete definition of this construct. One of the well-known definitions of engagement is the one suggested by Fredricks et al. [21]: engagement is a multidimensional construct that consists of three dimensions: (1) behavioral, which refers to involvement in academic and extracurricular activities and is linked to positive learning outcomes; (2) emotional, which includes positive and negative emotional reactions in a classroom that create a sense of identification with the school or institution; and (3) cognitive, which refers to "investment in learning", in other words, making the best effort to succeed in learning activities by using appropriate self-regulated learning strategies. There are also two lines of research around engagement: the first one developed around engagement in academic settings, and the second one evolved in the field of human–computer interaction to investigate how people perform activities using computer-based tools [22]. Regarding the first line of research, engagement can be described as

having a behavioral component of participation in learning activities, as well as having an emotional component of identification with those activities [23]. Emotional engagement represents the positive and negative affective reactions in the classroom, reactions to the school and teachers [21], and experiences of belonging to the school community [24].

Regarding the second line of research, O'Brien and Toms [25] developed a model of engagement based on the previous literature in the field of human–computer interaction to explain the experiences of people with technology. Engagement is considered to be a process that consists of four stages: the point of engagement, sustained engagement, disengagement, and reengagement [25]. It is also important to note that engagement as a process is influenced by some features of the system, some user traits, and the resulting interaction between the user and the system. In this line of research, previous studies have found that engagement with a virtual reality experience creates empathy [16]. In other words, engagement connects VR with empathy. However, Barbot and Kaufman [11] found that engagement was not a predictor of empathy change in immersive virtual reality environments. According to Witchel et al. [26], the relationship between empathy and engagement is not monotonic (either empathy is an antecedent of engagement or engagement is a sufficient but not necessary cause of empathy). Other researchers have used advanced methods such as electroencephalography (EEG) to obtain a more accurate and real-time estimation of engagement, and, consequently, more accurate models of flow have been defined [27]. These results open up possibilities for further research in the field of engagement in VR. In the same vein, Castiblanco Jimenez, Marcolin, et al. [28] presented a novel study using EEG to study the influence of color on emotions in VR and found that EEG can be used to determine emotional states and can complement self-reported measures. Usually, engagement has been measured using self-reported methods. However, these methods do not fully capture all of the aspects involved in engagement, so it is important to complement them. In that regard, Castiblanco Jimenez et al. [29] provided a framework describing other methods for measuring user engagement, such as skin conductance, heart rate, electroencephalography, pupillometry, and posture, which might be helpful in complementing self-reported measures and increase the reliability of collected data. Dubovi [30] concluded that physiological measures combined with self-reported measures are valuable for providing a holistic understanding of engagement. Since some contradictory and inconclusive results have been found in the literature, further research on the real effect of engagement on empathy is needed. In that regard, the following hypotheses are suggested to fill part of the gap in the literature regarding the effect of engagement on empathy:

H1: Engagement with a virtual reality environment has a positive and significant effect on emotional empathy.

H5: Engagement with a virtual reality environment has a positive and significant effect on cognitive empathy.

3.2. Immersion

The term immersion has been defined from different perspectives and is a multi-faceted concept [31]. For instance, Agrawal et al. [32] define immersion as "a phenomenon experienced by an individual when they are in a state of deep mental involvement in which their cognitive processes (with or without sensory stimulation) cause a shift in their attentional state such that one may experience disassociation from the awareness of the physical world". Similarly, immersion is defined as "a psychological state in which an individual believes him or herself to inhabit a setting that provides constant stimulation to which it is possible to respond" [33]. Immersion has been considered to be a psychological state that arises when a user experiences mental absorption in a virtual world as the result of a multisensory stimulation or the effect of a narrative that makes the user feel like they are part of the story [32].

Research on immersion in virtual reality has shown that a higher level of immersion can create more empathy than other media. This is because the stimuli in virtual reality experiences are closer to a direct experience; in other words, perspective taking is better in a fully immersive environment [34]. This view is supported by Herrera et al. [35], who found that VR-based perspective-taking tasks are more effective in creating empathy in a longitudinal intervention than less immersive tasks, such as narrative-based perspective-taking or imagine-self perspective-taking tasks. van Loon et al. [4] found that the sense of immersion in a VR perspective-taking experience moderates the level of cognitive empathy. This suggests that an important condition for eliciting empathy is ensuring that the participant experiences a certain amount of presence in the VR environment. Recent research has also shown that immersion in VR makes people feel spatially closer to a particular situation, and, therefore, the levels of empathy and pro-social behavior are higher [8]. Likewise, Rodríguez and Rozo [12] found that a videogame with a narrative about a Venezuelan migrant that moves to Colombia was more effective than a documentary on the same topic. The videogame was more effective because the role-playing experience and its immersive features facilitated perspective taking (cognitive empathy). Based on the literature, we suggest the following hypotheses:

H2: The sense of immersion in a virtual reality environment has a positive and significant effect on emotional empathy.

H6: The sense of immersion in a virtual reality environment has a positive and significant effect on cognitive empathy.

3.3. Compassion

There is a large body of research on compassion in the fields of psychology [36] and medicine [37], but research in the field started in the late 20th century. Compassion "involves being open to and moved by the suffering of others, so that one desires to ease their suffering" [38]. According to Singer and Klimecki [39], the term compassion is derived from the Latin word "compati" in which the prefix "com" means with or together and "pati" means "to suffer". This means to understand the suffering of others. Some authors have suggested that compassion is a component of a large construct called empathy. Compassion has been considered to be part of the empathy construct [40], while other authors have suggested that empathy is an antecedent of compassion because compassion involves more higher-level processes that require empathy [2]. Kim et al. [41] suggest that empathy mediates the relationship between gratitude and compassionate love (a more enduring form of compassion). According to Stevens and Taber [42], empathy consists of three components: emotional, cognitive, and behavioral (empathic concern). The third component is considered to be compassion. In that regard, compassion might be a component that influences empathy.

H3: Compassion for others has a positive and significant effect on emotional empathy when people use a virtual reality environment.

H7: Compassion for others has a positive and significant effect on cognitive empathy when people use a virtual reality environment.

Compassion acts as a mechanism of emotional regulation to elicit empathy so that a person is able to manage their own feelings in order to care for someone in a difficult situation [42]. In that regard, we suggest the following hypotheses in which compassion moderates the relationship between attitudes toward migrants and empathy:

H4a: Compassion for others has a positive and significant moderator effect between attitudes toward migrants and emotional empathy.

H8a: Compassion for others has a positive and significant moderator effect between attitudes toward migrants and cognitive empathy.

3.4. Attitudes toward Migrants

For the purposes of this study, a VR application developed by the authors was used to investigate the elicitation of empathy for migrants. In that regard, one of the aspects that might affect the levels of empathy is the perceived attitudes toward migrant populations. Previous research on attitudes toward migrants has focused on two perspectives: individual-level characteristics and contextual characteristics. The latter refer to migrants as a collective threat. Regarding contextual characteristics, previous studies analyzing the impact of migration flows on the labor market have shown that attitudes toward migration are based on a perceived threat rather than the actual competition of migrants [43]. "The fear of competition is more responsible for anti-migration attitudes than is the actuality of competition" [43]. In that regard, perceived attitudes toward migrants might have a positive influence on the empathy that can be developed via a VR application.

Miklikowska [44] found that empathy mediated the effect of parents' and peers' prejudice on adolescents' attitudes toward migrants. Likewise, in a sample of adolescents, Miklikowska [45] conducted a longitudinal study with self-reported measures to investigate attitudes toward migrants. The results showed that attitudes toward migrants did not have a significant effect on emotional and cognitive empathy in adolescents in public schools in Sweden. In contrast, Verkuyten et al. [46] found that perceptions about the reasons for migration (voluntary or involuntary) are related to empathy and support for migrants.

In general, previous research has focused on investigating the motivations behind attitudes toward migrants [47], but there is a lack of research on the effect that previous attitudes toward migrants might have on empathy when a VR application is used to elicit empathy for migrants. To fill this gap in the literature, in this study, we investigate how previous attitudes toward migrants might affect the levels of empathy that are created by a VR application. In that regard, we suggest the following hypotheses to investigate the effect of previous attitudes toward migrants on empathy:

H4: Reported attitudes toward migrants have a positive and significant effect on emotional empathy when people use a virtual reality environment.

H8: Reported attitudes toward migrants have a positive and significant effect on cognitive empathy when people use a virtual reality environment.

4. Methodology and Research Design

This study aimed to identify some of the predictors of emotional empathy and cognitive empathy during participants' use of a VR application about migration. To validate the structural model of the hypotheses, in this study, data were collected after each participant used a VR environment designed and developed by the authors. A description of the main features of the VR environment is presented in Section 4.1. The research procedure and instruments were approved by the Institutional Ethics Committee of the Fundación Universitaria Konrad Lorenz, where the research study took place. Informed consent was obtained from all participants, and the procedure was conducted in accordance with the Declaration of Helsinki [48].

4.1. VR Environment Used to Create Empathy for Migrants

The VR environment was developed in the Unity videogame engine for the Meta Quest and Meta Quest 2 VR headsets, with the purpose of creating empathy toward migration. The VR environment consisted of a small gallery with two rooms (Figure 1). In each room, the participants could see a 4 min long video with a story of a person who had to migrate from Venezuela to Colombia. Figure 2 shows a screenshot of the two rooms in the VR environment. One of the rooms (Figure 2b) told the story of a Venezuelan woman who lives in Bogotá (Colombia) and works as a waste picker. The second room (Figure 2a) told the story of a Venezuelan singer who also migrated and works as a singing teacher. Moreover, on the walls of each room, there were some pictures related to the story that was being presented in that room. The purpose of these pictures was to provide more context to the

story that was presented in each room and to increase the sense of immersion so that the participant could be really immersed in the presented story. The participant could choose the room that they wanted to visit and move freely in each room by teleporting in the VR environment using the Quest controller. The purpose of this VR environment was to provide a higher level of immersion to understand the migration stories and to study the factors that might influence empathy development in VR. A full technical description of the VR environment can be found in Bacca-Acosta et al. [49].



Figure 1. Top view of the VR environment.

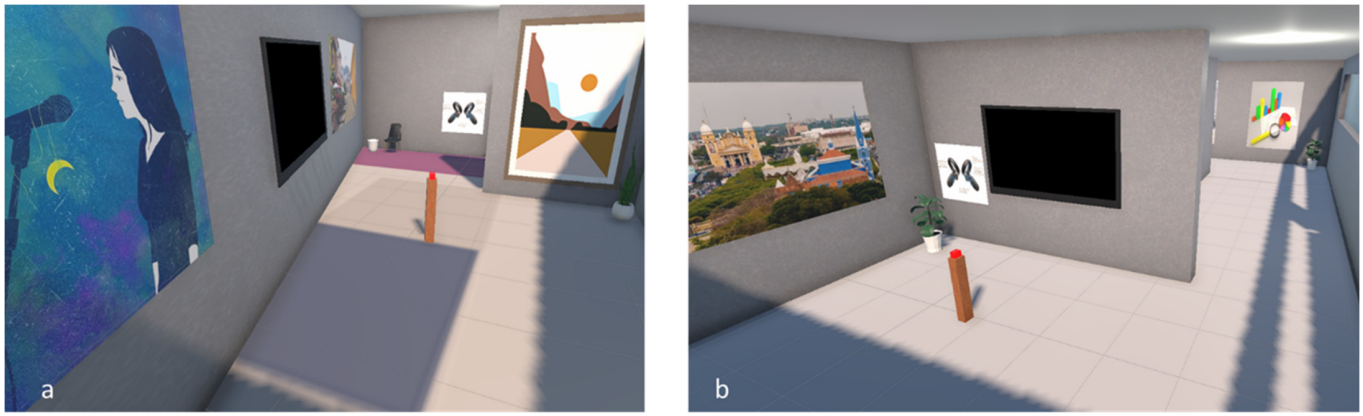

Figure 2. Screenshots of the two VR rooms. Each room showed the story of a person who had to migrate from Venezuela to Colombia: (**a**) the story of a Venezuelan singer who works as a singing teacher. (**b**) the story of a woman who works as a waste picker in Bogotá.

4.2. Participants

To determine the number of participants (sample size), we followed the minimum R-squared method, as suggested by Hair et al. [50]. In our structural model, we used five arrows as the maximum number of arrows pointing at the empathy variables; we defined a

5% probability error with a statistical power of 90% for detecting R^2 values of at least 0.25. Under these conditions, our study would require a minimum of 80 participants. However, to increase the validity of our model, in this study, 100 participants were recruited. The participants were 100 university students, of whom 51 belonged to the psychology program, 22 to the systems engineering program, 12 to the marketing program, 10 to the business administration program, and 5 to the mathematics program, with an average age of 20 years. Furthermore, 50 participants were female, and 50 were male. The participants were chosen through intentional sampling, and participation was voluntary. In this study, we chose a sample of university students because previous research has shown that treatments for pro-social behaviors are more effective with people in their impressionable years (18–25 years old) [51]. Students who had experienced a personal or family migration process were excluded in order to reduce the potential biases caused by previous experiences.

4.3. Instruments

A self-reported instrument was used to collect data. The reason for using a self-reported instrument was primarily the need to conduct a study with a large research sample (100 participants) in order to obtain sufficient data to validate a model using the PLS-SEM statistical technique. Moreover, the budget of the research project was limited, and we were not able to use more advanced equipment to collect other measures, such as physiological ones. The instrument consists of the following 6 scales for a total of 23 Likert-scale items: 5 items that assessed cognitive empathy plus 5 items that assessed emotional empathy were adapted from the Interpersonal Reactivity Index [52]. Cummings et al. [9] pointed out that previous research on the effect of VR on empathy has failed to consider empathy as a multidimensional construct. For that reason, in this study, we considered emotional and cognitive empathy as two dimensions of empathy. Three items assessing attitudes toward migrants were adapted from the immigration scale validated by Meuleman and Billiet [53]; three items assessing engagement were adapted from the User Engagement Scale [22] modified by Barbot and Kaufman [11]; three items assessing immersion were adapted from the instrument developed by Barbot and Kaufman [11]; and four items evaluating compassion were adapted from the Compassion Scale [54].

It is important to note that self-reported instruments have some disadvantages. For instance, some instruments do not fully capture the phenomena that are being measured, or some experiences are subconscious and cannot be fully expressed by people using a questionnaire. In that regard, physiological measures might be helpful for complementing self-reported instruments [29]. Physiological measures such as EEG together with self-reported measures have been found to be useful when measuring emotional processes [55].

4.4. Research Design

Figure 3 depicts the research procedure. The intervention was cross-sectional and lasted for 52 min in total.

Moreover, Figure 4 depicts the hypothesized model of the predictors of cognitive and emotional empathy that is formed with all of the hypotheses suggested in Section 3. In this model, the yellow boxes are the indicators of each construct, and the blue circles represent each one of the constructs. There are two additional green circles that represent the moderating effect of the attitudes toward migrants construct. This model was validated with the PLS-SEM technique, as described in detail in the next section (Section 5).

After introducing the proposed model of the predictors of emotional and cognitive empathy, the next section (Section 5) presents the validation of this structural model and describes the obtained results in detail.

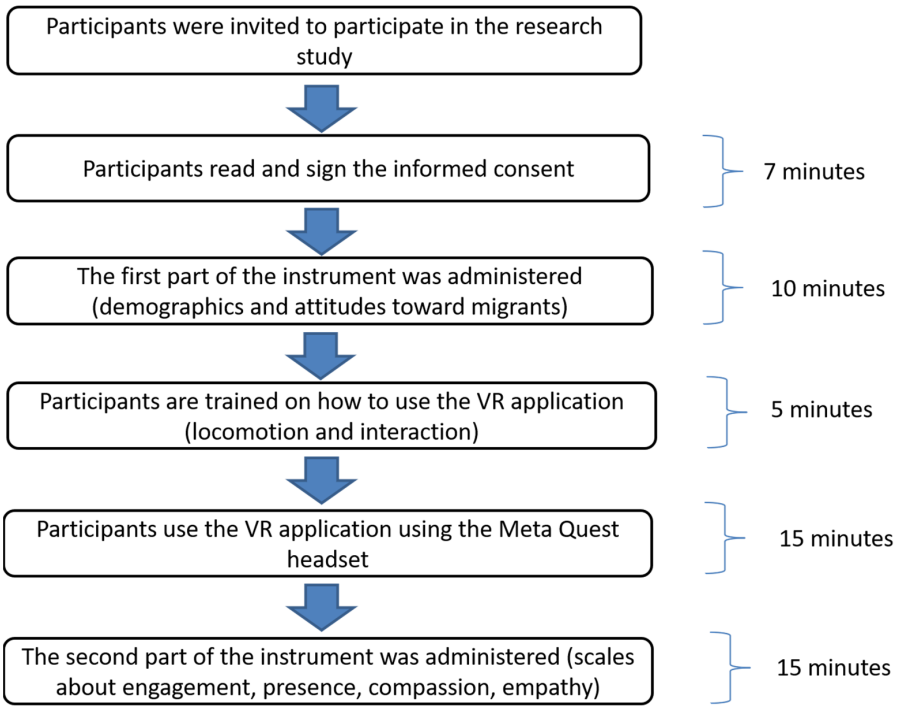

Figure 3. Research procedure.

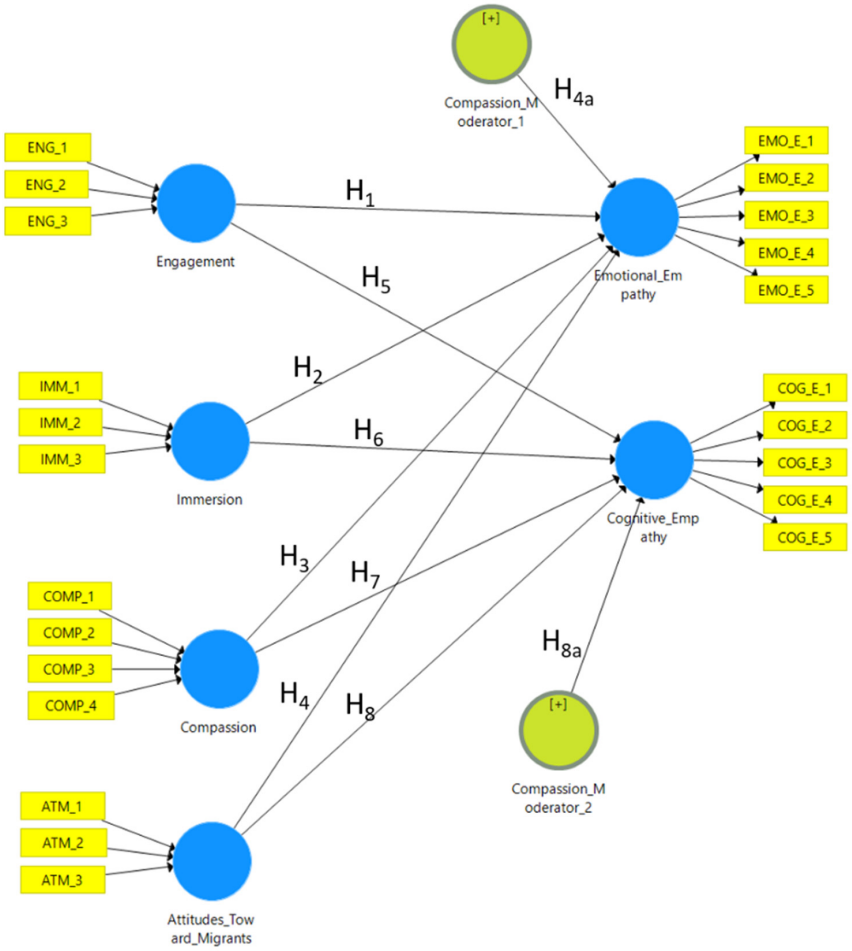

Figure 4. Hypothesized structural model of predictors of emotional and cognitive empathy.

5. Hypothesis Testing and Results

To validate the hypothesized model and identify the factors that influence emotional and cognitive empathy in a virtual reality environment about migration, partial least squares–structural equation modeling (PLS-SEM) was applied using the SmartPLS software package [56]. The evaluation of the structural model was divided into three steps according to Hair et al. [50]: an evaluation of the formative measurement model (see Section 5.1), an evaluation of the structural model (see Section 5.2), and an evaluation of the model's predictive relevance (see Section 5.3).

5.1. Evaluation of the Formative Measurement Model

The formative measurement model consists of the following exogenous variables with their corresponding indicators (see Figure 5): engagement, immersion, compassion, and attitudes toward migrants, as well as the moderator variable compassion. To evaluate this measurement model, redundancy analysis was applied to evaluate the convergent validity, as well as an analysis of collinearity through the variance inflation factor (VIF) and an analysis of the outer loadings [50]. The results are shown in Table 1. It is important to note that VIF measures multicollinearity, which means that two or more constructs in the model are correlated and measure the same attribute in the model. The average variance extracted (AVE) indicates how much of the variance in each construct is explained by the items used for that construct. Ideally, AVE should be higher than 0.5, indicating that the explained variance is due to the constructs and not due to an error.

Table 1. Outer loadings, convergent validity, composite reliability, VIF, and AVE of the formative measurement model.

Formative Constructs	Indicators for the Construct	Outer Loadings (>0.5)	Convergent Validity—Redundancy Analysis (>0.7)	Collinearity (VIF < 5)	Composite Reliability (>0.7)	AVE (>0.5)
Engagement			1.000		0.902	0.755
	ENG_1	0.618		2.466		
	ENG_2	0.999		1.173		
	ENG_3	0.656		2.192		
Immersion			1.000		0.759	0.533
	IMM_1	0.731		2.260		
	IMM_2	0.662		2.266		
	IMM_3	0.656		1.025		
Compassion			1.000		0.913	0.726
	COMP_1	0.984		2.685		
	COMP_2	0.804		3.054		
	COMP_3	0.833		2.863		
	COMP_4	0.500		1.503		
Attitudes Toward Migrants			1.000		0.772	0.536
	ATM_1	0.597		1.210		
	ATM_2	0.961		1.211		
	ATM_3	0.500		1.153		

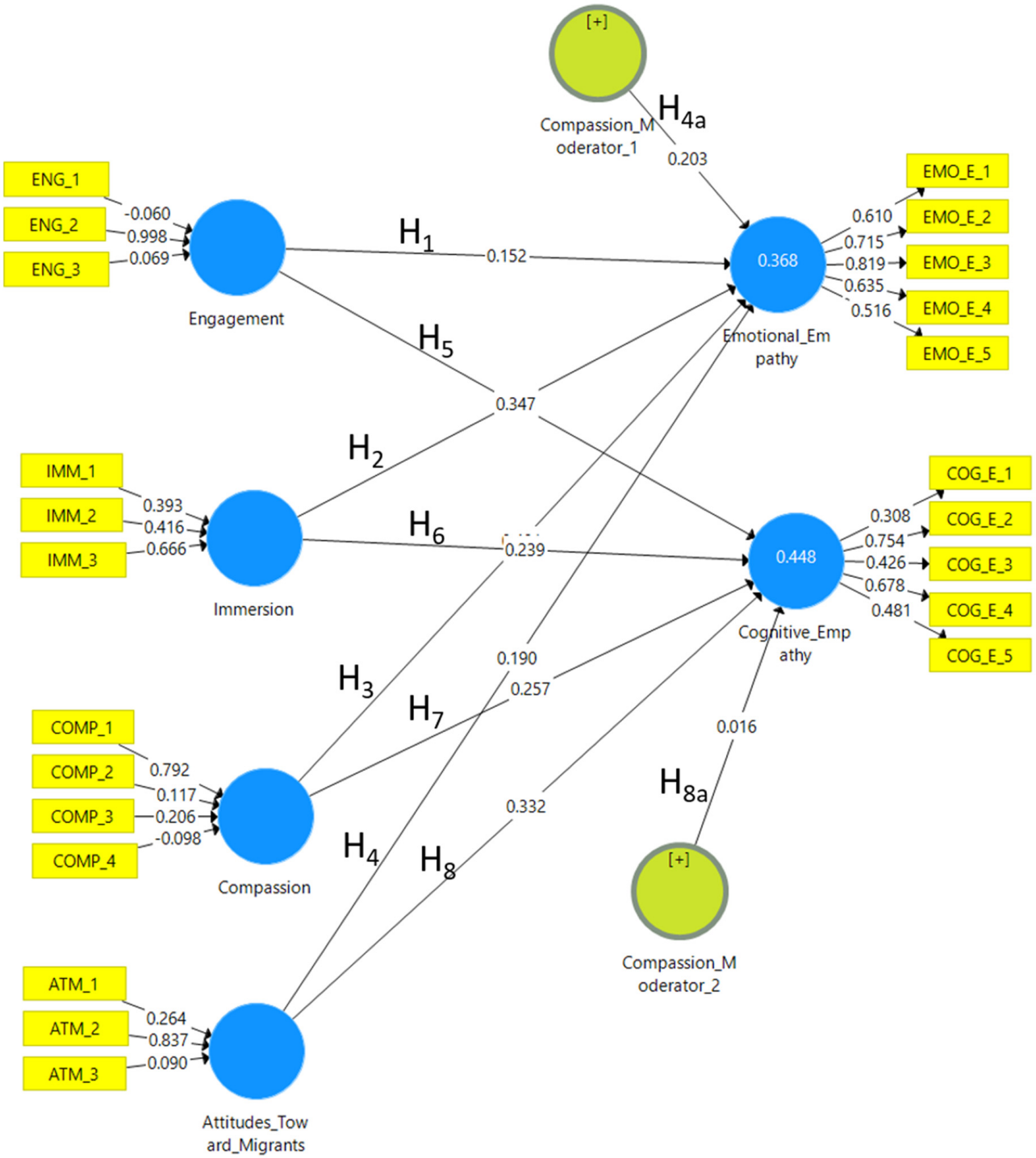

Figure 5. Validated model of predictors of emotional and cognitive empathy.

5.2. Evaluation of the Structural Model

To evaluate the structural model in SmartPLS, the recommended method is bootstrapping [50]. Table 2 shows the results of R^2 and R^2 (adjusted) for each endogenous latent construct (dependent variables) in the model, as well as the total effects and indirect effects of the exogenous constructs (independent variables).

Table 2. Results of R^2, R^2 adjusted, total effects, and indirect effects of the structural model.

Dependent Variable	Independent Variable	R^2 (R^2 Adjusted)	Total Effects
Emotional Empathy		0.448 (0.419)	
	Engagement		0.152
	Immersion		0.127
	Compassion		0.401
	Attitudes Toward Migrants		0.190
	Compassion as Moderator		0.203
Cognitive Empathy		0.368 (0.335)	
	Engagement		0.347
	Immersion		0.239
	Compassion		0.257
	Attitudes Toward Migrants		0.332
	Compassion as Moderator		0.016

The results in Table 2 (above) show that the model explains 44.8% of the variance in emotional empathy. All of the factors have a positive effect on emotional empathy, and the factor with the strongest effect is compassion (0.401), followed by attitudes toward migrants. Moreover, compassion as a moderating factor positively influences (0.203) the relationship between attitudes toward migrants and emotional empathy.

Furthermore, the model explains 36.8% of the variance in cognitive empathy as a result of the positive effect of engagement (0.347), attitudes toward migrants (0.332), compassion (0.257), and immersion (0.239). Compassion as a moderator variable has almost no effect on cognitive empathy.

Table 3 shows the paths in the hypothesized model, together with the path coefficients, effect size, t-value, *p*-value, and an indicator of whether the hypothesis was supported as a result of the PLS-SEM analysis.

Table 3 shows that five out of the eight hypotheses in the model are supported. In summary, on the one hand, compassion and attitudes toward migrants predict emotional empathy in a VR environment about migration. Moreover, compassion is a factor that moderates the effect of attitudes toward migrants on emotional empathy. On the other hand, engagement, immersion, compassion, and attitudes toward migrants are factors that predict cognitive empathy in a VR environment about migration.

Figure 5 shows the validated model of the predictors of emotional and cognitive empathy, including the path coefficients and outer loadings.

Table 3. Results of the hypothesis testing in the structural model.

Hypothesis	Path	Path Coefficient	Effect Size (f^2)	t-Value	*p*-Value	Supported
H1	Engagement → Emotional Empathy	0.152	0.027	1.467	0.143	No
H2	Immersion → Emotional Empathy	0.127	0.019	1.161	0.246	No
H3	Compassion → Emotional Empathy	0.401	0.221	4.489	<0.001	Yes
H4	Attitudes Toward Migrants → Emotional Empathy	0.190	0.056	2.201	0.044	Yes

Table 3. *Cont.*

Hypothesis	Path	Path Coefficient	Effect Size (f^2)	t-Value	*p*-Value	Supported
H4a	Attitudes Toward Migrants → Emotional Empathy (Moderated by Compassion)	0.203	0.068	2.522	0.012	Yes
H5	Engagement → Cognitive Empathy	0.347	0.166	3.170	0.002	Yes
H6	Immersion → Cognitive Empathy	0.239	0.076	2.400	0.017	Yes
H7	Compassion → Cognitive Empathy	0.257	0.111	2.588	0.010	Yes
H8	Attitudes Toward Migrants → Cognitive Empathy	0.332	0.197	3.237	0.001	Yes
H8a	Attitudes Toward Migrants → Cognitive Empathy (Moderated by Compassion)	0.016	0.001	0.236	0.813	No

5.3. Predictive Relevance of the Structural Model

To evaluate the predictive relevance, Stone–Geisser's Q^2 measure was used, as recommended by Hair et al. [50]. The predictive relevance is useful to determine how well the model predicts the original values. In other words, this measure was used to indicate how well the model could predict cognitive and emotional empathy. To calculate Stone–Geisser's Q^2 measure, in SmartPLS, the blindfolding method was applied with an omission distance of 7 and using the cross-validated redundancy. The results (See Table 4) show that emotional empathy exhibits a high predictive power in our model.

Table 4. Stone–Geisser's Q^2 measure for predictive relevance of the structural model.

Endogenous Variables	Stone–Geisser's (Q^2)
Emotional Empathy	0.127
Cognitive Empathy	0.087

Moreover, the effect size (q^2) was also computed to determine the relative predictive relevance of each exogenous construct with respect to the endogenous constructs. Following the recommendations of Hair et al. [50], the effect size was calculated from Stone–Geisser's Q^2 measure. Table 5 shows the values of the q^2 effect sizes. The columns represent the endogenous variables, and the rows represent the predictors. Values of 0.02, 0.15, and 0.35 indicate small, medium, and large effect sizes, respectively.

Table 5. Values of the q^2 effect size.

	Emotional Empathy	Cognitive Empathy
Engagement	0.008	0.020
Immersion	0.004	0.010
Compassion	0.101	0.010
Attitudes Toward Migrants	0.026	0.005
Compassion Moderating Emotional Empathy	0.0149	
Compassion Moderating Cognitive Empathy		−0.010

6. Discussion

In this study, a structural model based on hypotheses derived from the literature was validated using the PLS-SEM technique to identify the factors that influence emotional and

cognitive empathy when a VR environment is used to elicit empathy toward migration. Despite the fact that the intervention was cross-sectional, the results show that the model explained 44.8% of the variance in emotional empathy as a result of the positive influence of compassion and attitudes toward migrants.

Regarding compassion, the results confirm that compassion is a factor that has a positive influence on emotional empathy. The effect size (q^2) value of the compassion construct with respect to emotional empathy was medium and close to high (0.101). This result is in line with that in previous studies claiming that compassion can be part of the larger construct "empathy" [40]. In that regard, the levels of compassion for migrants generated using a VR environment seem to be key to creating empathy. This result has implications for designers of VR experiences because VR experiences should include aspects that increase compassion in order to boost emotional empathy. However, our results are not in line with those of other researchers claiming that empathy is an antecedent of compassion [2,41]. In that regard, further research needs to be conducted on the relationship between empathy and compassion.

The results also show that attitudes toward migrants have a positive and significant influence on emotional empathy but with a small (q^2) effect size (0.026). A possible interpretation of this result is that prejudices about migration influenced the levels of empathy elicited by the experience in the VR environment. This result is in line with the results of Young et al. [5], who found that participants' attitudes toward the protagonist in a VR experience differ significantly between subjects and influence the level of empathy but that the modality of the experience (a 360° video vs. an immersive documentary) has no effect on empathy. Our result also contributes to the body of research on attitudes toward migrants by evaluating their effect on emotional empathy when a VR environment is used to elicit empathy toward migration. The result also has implications for designers of VR environments. For instance, future VR experiences about migration might include adaptive or personalization processes [57,58] that take into account the attitudes toward migrants in a user model to adapt the VR experience depending on the user's prejudices. Furthermore, previous research on attitudes toward migrants has been conducted with adolescents in schools [44,45]. However, research on the effect of the attitudes of higher-education students toward migrants using a VR environment as a medium to elicit empathy is still scarce.

The results also show that the proposed model explained 36.8% of the variance in cognitive empathy as a result of the positive influence of engagement, attitudes toward migrants, compassion, and immersion. This result outperforms the result of a previous model developed by Barbot and Kaufman [11] that explain changes in empathy in VR environments. Compassion as a moderator variable had almost no effect on cognitive empathy. The reason behind the minimal effect of compassion on cognitive empathy might be explained theoretically by previous research in the field of psychology, showing that compassion belongs to socio-affective processes that activate a particular region in the brain but that cognitive empathy activates a different region in the brain that is related to socio-cognitive processes (perspective taking). Although both processes are complementary to each other, the influence of one on the other is limited [59]. Moreover, compassion seems to be a factor that defines the third component of empathy, which is called empathic concern, but this is not yet completely clear in the research on empathy. Compassion works as a component of emotional regulation that leads to pro-social behaviors [42]. If we assume that compassion is the third component of empathy, together with cognitive empathy and emotional empathy, then the influence of compassion on cognitive empathy is limited. From the perspective of the VR experience, the reason for this result might be explained by the fact that the VR experience did not include an embodied experience, and, therefore, the elicitation of cognitive empathy was limited because the experience did not create a full sense of perspective taking.

If we compare the levels of emotional empathy explained by our model (44.8%) and the levels of cognitive empathy explained by our model (36.8%), we can observe a small

difference in which the explained variance in cognitive empathy is lower. An interpretation of this result might be that the lower level of cognitive empathy is the result of a VR experience without embodiment. In other words, in the VR experience built for this study, the user is not embodied in the migrant and is a passive user. Consequently, perspective taking is restricted, and, therefore, cognitive empathy is affected. In this regard, we suggest that future VR environments developed to create empathy toward migration should include user embodiment to increase cognitive empathy to a greater level. Another interpretation of this result might be that the participant in the VR experience empathizes with the designer's perspective of the real situation and not directly with the subject. In other words, the viewer experiences the designer's perspective of the real situation that is represented in VR. This is called empathic actuality [60].

Regarding engagement, the results of this study corroborate the findings of other researchers who noted the importance of engagement as a process that connects the VR experience to empathy [16]. Our results extend the findings of Witchel et al. [26] by confirming that engagement predicts empathy in VR experiences about migration. The effect size (q^2) value of the engagement construct with respect to emotional empathy was small (0.020). However, our results contradict the findings of Shin [61], who stated that empathy is a predictor of engagement in a VR experience.

In this study, we found that attitudes toward migrants predict the levels of cognitive empathy. This result corroborates the findings by Young et al. [5] regarding the effect of attitudes toward the protagonist of a VR experience on empathy. Moreover, to the best of our knowledge, this is the first study suggesting that participants' attitudes toward migrants predict cognitive empathy in VR experiences about migration. An implication of this result is that future VR experiences developed to elicit empathy toward migration should consider previous attitudes toward migrants to effectively create empathy. To interpret the results, it is also important to note that this study was conducted after the COVID-19 crisis, and previous research has found that people's perceptions of a crisis (such as the COVID-19 pandemic) significantly affect their attitudes toward migrants [51].

We also found that compassion predicts cognitive empathy, with a small effect size value ($q^2 = 0.010$). This result contributes to the body of research on empathy. In particular, our result confirms that compassion might be a factor that predicts empathy, and, therefore, our result contradicts the claim that empathy is an antecedent of compassion [40]. Recent research has shown that emotional empathy increases compassion fatigue but that cognitive empathy reduces compassion fatigue [62]. However, our results might suggest that compassion could be one of the components of empathy. In that regard, our result confirms the previous findings by Stevens and Taber [42]. Since there are still mixed results, we call for more research to uncover the relationship between empathy and compassion.

Finally, the results show that immersion is also a predictor of cognitive empathy, with a small effect size value ($q^2 = 0.010$). The interpretation of this result is that the level of immersion in VR increases the possibility of participants feeling like they are in someone else's shoes. This indicates perspective taking, in other words, cognitive empathy. This result echoes that of previous research that found evidence of the effect of immersion on cognitive empathy [4,8,34,35].

7. Limitations

The results of this study should be interpreted with caution because the VR environment used in this study was developed only to create empathy for migrants. The predictors of empathy identified in this study cannot be generalized to other domains (apart from migration) without further validation of this model in other fields. The model that we suggested and validated in this paper was created based on the literature around empathy and VR (apart from the variable of attitudes toward migrants), so the model can be validated easily without any changes using VR environments developed for topics other than migration. In that regard, the model can be easily applied to other domains to identify predictors of empathy. In this study, we found some factors in the literature that influence

empathy, but there might be more underlying factors. The intervention with the VR application was cross-sectional, and, consequently, the effect of some factors might decrease or increase with time, but the results show a positive effect for shorter interventions with VR. In this study, we used self-reported measures that have some associated drawbacks. In that regard, future research might use physiological measures, such as those suggested by Castiblanco Jimenez et al. [29], to obtain a more holistic understanding of how empathy is developed in VR.

8. Conclusions and Future Work

In this study, we found some direct predictors of emotional and cognitive empathy during the participants' use of an immersive VR environment about migration. The suggested model explained 44.8% of the variance in emotional empathy as a result of the positive influence of compassion and attitudes toward migrants. Furthermore, compassion is a moderator construct between attitudes toward migrants and emotional empathy. Moreover, the suggested model explained 36.8% of the variance in cognitive empathy as a result of the positive influence of engagement, attitudes toward migrants, compassion, and immersion. To the best of our knowledge, this is the first study that identifies some of the predictors of empathy when VR is used as a medium. The main contribution of this study is the definition of the first model that explains how empathy is elicited in VR. The model introduced in this paper can be validated in other fields to confirm whether these predictors are effective predictors of empathy in VR. Moreover, the model introduced in this paper can be the baseline of extended models by adding more variables or constructs to explain empathy. Some variables that might be included in an extended model are presence, immersion, usability, and agency.

Overall, the results in this study contribute to the body of research on the aspects of VR experiences that are key to eliciting empathy. In particular, our results confirm previous findings regarding the potential of VR for eliciting empathy [63]. Moreover, previous research has shown that a VR environment is equally effective in eliciting empathy as a real embodied experience [64]. This means that VR is capable of creating conditions to train empathy at a reasonable cost without the need for additional resources, such as exposing participants to real settings that might be difficult in practice, or when a face-to-face encounter with a person is difficult or impossible [7].

Future research directions in this field include further research on other factors that might influence empathy, such as presence, embodiment, user experience, and usability. Moreover, the integration of a co-creation methodology in which migrants can participate in the design and development of a VR experience to elicit empathy toward migration might be key to overcoming the phenomenon of empathic actuality suggested by Fisher (2017). Furthermore, future research should consider longitudinal interventions with VR to investigate how some factors affect empathy and how immersive storytelling elicits empathy [65]. A future research direction might be to validate the model introduced in this paper in a VR application that includes embodiment to improve perspective taking and to achieve better results in cognitive empathy. Another avenue for research is to use physiological measures, such as the ones suggested by Castiblanco Jimenez et al. [29], to identify how empathy is developed in VR. Finally, further research should explore more aspects that influence the effect of attitudes toward migrants on empathy when VR environments are used to elicit empathy toward migration processes.

Author Contributions: Conceptualization, M.S.-P. and J.B.-A.; Methodology, J.B.-A.; Validation and Data Collection, C.A.-G. and M.S.-P.; Formal Analysis, J.B.-A.; Investigation, C.A.-G.; Writing—Original Draft Preparation, J.B.-A.; Writing—Review and Editing, C.A.-G.; Funding Acquisition, J.B.-A. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by COMISIÓN DE REGULACIÓN DE COMUNICACIONES—CRC and MINISTERIO DE CIENCIA, TECNOLOGIA E INNOVACIÓN from Colombia under the contract 80740-084-2022. The research was also funded by the Fundación Universitaria Konrad Lorenz under

the Project 5INV8221. This article belongs to the products of the research project entitled "Co-creación de narrativas inmersivas sobre migración en Colombia: una propuesta metodológica" presented and approved under research call 908 from MINCIENCIAS "Nuevo conocimiento, desarrollo tecnológico e innovación para el fortalecimiento de los sectores de TIC, postal y de contenidos audiovisuales".

Data Availability Statement: The data presented in this study are openly available in OSF at https://osf.io/gax24/?view_only=0758d6af747b4073aa6c7b176c0f3a34 (accessed on 26 June 2023).

Acknowledgments: Thanks to the Interactivity Lab from the Fundación Universitaria Konrad Lorenz where the intervention was carried out. We acknowledge the support of Emiliano Hurtado who contributed to the development of the first version of the VR application.

Conflicts of Interest: The authors declare no conflict of interest.

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