

# Immersive technologies as effective as 2D in improving forest conservation behaviors<sup>\*</sup>

Alipio Ferreira      Sanchayan Banerjee

April 6, 2024

## Abstract

Immersive technologies, such as virtual reality (VR), are rapidly reshaping our methods of communication by transforming our perception of the natural world, eliciting profound emotional responses, and potentially improving pro-environmental attitudes. However, there is limited evidence of their impact in eliciting pro-conservation actions, and of the additional impact of VR relative to more conventional technologies, such as a 2D video. Collaborating with an international conservation organization, we estimated the impact of a movie shown through VR and conventional 2D methods on forest conservation behaviors. Using a preregistered field experiment conducted in a Brazilian shopping mall, we randomly assigned 617 shoppers to watch either an immersive video clip about the Amazon Forest through VR or a traditional 2D device (treatments 1 and 2). Moreover, we randomly collected data for some participants before showing them the movie (control group). We found that both the 2D and VR video messaging interventions significantly increased individuals' propensity to i) contribute to the Amazonian humanitarian campaign, ii) share their contact information, iii) interact with the social media campaign, and iv) state more pro-conservation opinions. However, the VR movie did not have significantly larger effects than the 2D experience, despite larger coefficients in some outcomes. Three months after the experiment, we followed up with those who willingly shared their contact information, and received significantly greater engagement from participants who had watched the VR movie. Our findings provide cautionary evidence about the additional potential of using immersive technologies to improve pro-environmental outcomes relative to 2D movies.

---

<sup>\*</sup>Alipio Ferreira: Southern Methodist University, alipioferreira@smu.edu; Sanchayan Banerjee: Institute for Environmental Studies, Vrije Universiteit Amsterdam, s.banerjee@vu.nl. We thank Interfaith Rainforest Initiative Brazil, Shopping Conjunto Nacional, and Abdul Latif Jameel Poverty Action Lab's Latin American Office for their logistical and financial support. We especially thank the support by Carlos Vicente from Interfaith Rainforest Initiative, and insightful discussions with him, José Moulin, and Francisco Almendra. The experiment protocol was reviewed and approved by the Ethical Review Board of Inesper (report 296/2023 emitted on June 19, 2023).

## 27 **Introduction**

28 Immersive technology, such as virtual reality (VR), is rapidly reshaping our connection and  
29 communication methods. Immersive experiences within virtual environments can elicit pro-  
30 found emotional responses and procure the attention of the viewer, enabling the more effective  
31 transmission of messages and ideas. VR technologies have been posited as a potentially ef-  
32 fective tool to enhance awareness about environmental problems, for example, by helping  
33 individuals visualise and comprehend future climate scenarios, otherwise perceived as dis-  
34 tant and abstract. VR allows for the possibility of delivering immersive experiences without  
35 needing to physically displace viewers to other contexts or locations and therefore, it has the  
36 potential to foster pro-environmental attitudes in large population settings. However, there  
37 is very little evidence from the field on the effectiveness of using these immersive technologies.  
38 We fill this gap by testing the role of VR in facilitating information messaging to improve  
39 local conservation efforts in the Amazonian rainforest.

40 Specifically, we designed and administered a preregistered field experiment, jointly un-  
41 dertaken with the UN-sponsored Interfaith Rain forest Initiative (IRI) project, in a shopping  
42 mall in Brasília (Brazil). Passers-by in the shopping mall (N=617) were invited to watch a  
43 movie, randomly in a VR or a 2D setting. All individuals were surveyed, with some randomly  
44 surveyed only after watching the movie, and others both before watching it. Set up this way,  
45 we had a control group made of individuals interviewed before watching any movie and two  
46 treatment groups interviewed after watching the movie but varying in the medium of the in-  
47 formation (2D versus VR). In other words, by surveying passers-by before they were exposed  
48 to any information messaging, we measured their pre-treatment beliefs, pro-environmental  
49 attitudes, and pro-social outcomes (namely, willingness to support a local rain forest con-  
50 servation campaign, donation to a rain forest conservation charity, and willingness to share  
51 contact information for future contact). The individuals in the control group also watched  
52 the movie (randomly in 2D or VR format) and were allowed to update their answers if they  
53 wanted to.

54 The movie, in the VR or 2D conditions, was produced by the Interfaith Rainforest Ini-  
55 tiative. The movie lasted approximately 10 minutes and was an artistic rendering of a visit  
56 to the Tapajós region in the Brazilian Amazon Forest, and was awarded the “Best VR Film  
57 Prize” at the Barcelona Planet Film Festival 2023. The movie, filmed with a 360-degree  
58 camera, takes the viewer on a virtual trip to the Brazilian Amazon Forest, guided by an  
59 indigenous girl who talks about its beauties and indigenous traditions. She guides the viewer  
60 by highlighting the region’s biodiversity in flora and fauna and deploring forest destruction,  
61 at which moment the movie shows a forest fire. The movie ends with the girl paying homage  
62 to nature by singing a prayer in an indigenous language. When watched on a VR headset,  
63 the movie gives viewers an active role in deciding what to look at, as they can turn their  
64 heads and look in all possible directions. This active engagement is unavailable in the 2D

65 movie. More details about our experimental design are available in the Methods.

66 We find that after watching the movie (2D or VR), participants report significantly  
67 stronger pro-environmental attitudes and are more likely to take concrete pro-environmental  
68 actions. However, participants who watched the VR version of the movie did not engage in  
69 meaningfully different actions compared to participants who watched the 2D version. More  
70 specifically, participants were 10 p.p. (2D) and 12 p.p. (VR) more likely to enter the sug-  
71 gested web page of a conservationist movement after watching the movie, with no statistical  
72 difference between the two movie formats. Further, there was no impact on the probability  
73 of sharing a post by the said movement on their social media. After watching the movie,  
74 participants were also 11 p.p. more likely to share their WhatsApp number with the re-  
75 search team to receive more information about environmental campaigns by the Interfaith  
76 Rainforest Initiative, and again there was no statistically significant difference between the  
77 two treatments. Finally, we find that the VR movie increased the propensity to make a  
78 financial donation to a humanitarian cause for indigenous peoples in the Amazon Forest by  
79 9 p.p. (statistically significant at the 5% level) relative to the control group, whereas the 2D  
80 version increased it by 4 p.p. (not statistically significant). All these effects are robust to the  
81 inclusion of demographic controls, enumerator fixed effects, and survey day fixed effects.

82 As a follow-up to the experiment, we also contacted participants who had shared their  
83 WhatsApp numbers with the research team (in the control and treatment groups) three  
84 months after the experiment. We sent each participant a personalized link that landed on the  
85 official web page of the movie they had watched. The web page contains detailed information  
86 about the movie and videos with testimonials from influential people who have watched it.  
87 We tracked how many people clicked on the link, comparing the group that watched the 2D  
88 versus the VR movie (all participants, including the control group, eventually watched one  
89 version of the movie). Approximately 9% of participants who had watched the VR movie  
90 clicked on the link, versus 4.5% among participants who had watched the 2D movie. This  
91 difference is statistically significant at the 10% level. Once again, our results are robust to  
92 different econometric specifications, such as controlling for socio-demographic characteristics  
93 and enumerator and time-fixed effects.

94 Our findings highlight the need to assess the benefits of immersive technologies as a  
95 medium of communication to facilitate pro-environmental actions more critically. In our ex-  
96 periment, immersive experiences impacted participants' environmental attitudes and actions  
97 mildly, with the VR version displaying stronger effects than the 2D version only in the dis-  
98 tant future. These technologies could likely lead to more persistent behaviour change given  
99 their immersive experience, however, we do not find very strong evidence for this. We also  
100 cannot discount if these long-term effects are driven by the novelty factor of the first contact  
101 with VR headsets. As such, given these findings, we suggest that practitioners should exert  
102 caution in scaling up the use of these technologies – given such low benefits yet high costs

103 of implementation, it is likely that immersive technologies would not surpass conventional  
104 technologies in their cost-effectiveness for improving sustainable outcomes. We are hopeful,  
105 however, that our pessimism will be relieved in the long term with reduced costs of VR  
106 implementation and more external tests of such technologies.

## 107 **Results**

### 108 **No short-term differences between 2D and VR formats**

109 Our first set of outcomes, all pre-registered, reflect pro-conservation actions taken by the  
110 participants: the willingness to search for information about a conservation campaign (“See  
111 Page”), to share a post by the same conservation campaign on social media (“Share”), to  
112 share their personal contact information for future contact (“WhatsApp”), to make a financial  
113 donation to a rain forest conservation charity (“donation”). We also recorded the value of  
114 the donation. All outcomes were observed actions taken (or not) before the enumerator. To  
115 measure the impact of the movie on people’s actions, we compare the outcomes of the two  
116 treatment groups, that is, individuals who were interviewed after they were shown the movie  
117 in the VR or 2D format, with the control group, that is, those who were interviewed just  
118 before being shown any movie.<sup>1</sup>

119 Table 1 presents these findings using linear regression models using three different spec-  
120 ifications. Panel A shows the estimated coefficients without controls, Panel B shows the  
121 coefficients of the regressions with demographic controls, and Panel C adds enumerator fixed  
122 effects and survey date fixed effects. In all specifications, statistical inference is done using  
123 heteroskedasticity-robust White standard errors.

124 We see that both VR and 2D formats effectively increase participants’ participation in  
125 pro-conservation behaviors relative to the baseline. For example, participants who watched  
126 the 2D and VR were 10 p.p. and 12 p.p. more likely to enter the suggested web page  
127 of a conservationist movement after watching the movie using their smartphones. However,  
128 despite viewing these pages, we did not find a significant impact on the probability of sharing  
129 this post on their social media for any treatment group. Participants were also 11 p.p. more  
130 likely to share their WhatsApp number with the research team to receive more information  
131 about environmental campaigns, with the coefficient being almost identical in both treatment  
132 groups.

---

<sup>1</sup>As explained above, the decision to interview the participant before or after the movie was random. The control and treatment groups have no overlapping individuals.

Table 1: Treatment effects estimation on actions

	P(see page)	P(share)	P(whatsapp)	P(donation)	Donation
<b>Panel A: no controls</b>					
	(1)	(2)	(3)	(4)	(5)
2D	0.100** (0.0481)	0.0449 (0.0483)	0.102** (0.0488)	0.0298 (0.0420)	0.681* (0.375)
VR	0.127*** (0.0458)	0.0226 (0.0461)	0.100** (0.0471)	0.0827** (0.0417)	0.217 (0.273)
R2	0.0136	0.00141	0.00983	0.00655	0.00669
p-value $\beta^{VR} = \beta^{2D}$	0.568	0.644	0.966	0.228	0.217
<b>Panel B: + controls</b>					
	(1)	(2)	(3)	(4)	(5)
2D	0.103** (0.0464)	0.0386 (0.0476)	0.105** (0.0493)	0.0304 (0.0431)	0.718** (0.363)
VR	0.123*** (0.0452)	0.0213 (0.0455)	0.0960** (0.0471)	0.0842** (0.0421)	0.185 (0.273)
R2	0.0823	0.0660	0.0230	0.0139	0.0301
p-value $\beta^{VR} = \beta^{2D}$	0.654	0.714	0.844	0.231	0.154
<b>Panel C: + enumerator and survey day fixed effects</b>					
	(1)	(2)	(3)	(4)	(5)
2D	0.0870* (0.0464)	0.0215 (0.0432)	0.106** (0.0485)	0.0432 (0.0395)	0.623* (0.343)
VR	0.125*** (0.0446)	0.0183 (0.0408)	0.0983** (0.0465)	0.0720* (0.0368)	0.182 (0.275)
R2	0.119	0.253	0.0597	0.219	0.0762
p-value $\beta^{VR} = \beta^{2D}$	0.394	0.941	0.868	0.477	0.205
N	617	617	617	617	617
Mean control	0.586	0.338	0.557	0.210	0.595

Obs: \* 0.10 \*\* 0.05 \*\*\* 0.01 significance levels. This table shows the results for OLS regressions of the outcomes (in columns) on the treatment. The two treatment groups refer to people who were randomly selected to watch the movie *Amazônia Viva* and were interviewed after watching the movie. These participants were randomly selected to watch one of the two versions of the movie (2D or VR format). The control group comprises participants randomly assigned to be interviewed before watching the movie. Panel A shows the results for the simple specification without any controls. Panel B controls for dummies of religion (Catholic, evangelical, atheist, no religion, others), dummies of highest attained education level (incomplete basic education, complete basic education, incomplete higher education, complete higher education, graduate studies), and age in years. Panel C shows the specification for the same set of controls, plus dummies for the enumerator who conducted the interview. In all specifications, inference is done by computing robust (White) standard errors.

133 Finally, we found that the VR movie increased the propensity to make a financial donation  
134 to a humanitarian cause for indigenous peoples in the Amazon Forest by 9 p.p., whereas there  
135 was no significant difference observed for the 2D format with respect to the control group.  
136 However, the mean value of donations was only statistically different from the control group's

137 mean donation value for the 2D group, suggesting that an increase in propensity to donate  
138 in the VR condition did not translate into higher donations. All these findings are robust  
139 across the three specifications.

140 Although both the VR and 2D formats are individually effective versus the baseline for  
141 several outcomes, we do not find significant differences between the effect of 2D and VR. The  
142 coefficients are too similar to be statistically distinguishable from one another at conventional  
143 significance levels. Table 1 shows the p-values of equality tests between the coefficients, all  
144 of them being larger than 20%. These results suggest that the two interventions seem to  
145 activate similar responses in viewers. However, we cannot exclude that our experimental  
146 design was insufficiently powered to detect small treatment effects between 2D and VR, but  
147 this only suggests that even if such a difference indeed exists, it is likely very small relative  
148 to the effect of either intervention with respect to the control group.

149 As a follow-up to the experiment, we also contacted participants who had shared their  
150 WhatsApp numbers with the research team (in the control and treatment groups) three  
151 months after the experiment. In this intervention, all participants had watched the movie,  
152 so we only compared those who watched the VR with those who watched the 2D version.  
153 We sent each participant a personalized link that landed on the official web page of the  
154 movie they had watched. On tracking engagement with the link, by comparing individuals  
155 in the two conditions, we find that 9% of participants who had watched the VR movie  
156 eventually clicked on the link, whereas only 4.5% in the 2D condition clicked on the link.  
157 This difference is statistically significant at the 10% significance level, as shown in Table  
158 2, and it is robust to the inclusion of demographic controls and enumerator fixed effects  
159 (Columns 1, 2, and 3). There was no difference in the number of clicks on the link (Columns  
160 4, 5 and 6). Moreover, when using only the control individuals (that is, individuals who gave  
161 their WhatsApp before watching any movie) we do not find any statistical difference. Note  
162 that we did not pre-register this test and, therefore, this finding is exploratory.

## 163 **Impacts on self-reported beliefs and attitudes**

164 We also assessed the impact of the intervention on self-reported beliefs and attitudes of  
165 individuals, again by comparing the stated answers of individuals after watching the VR and  
166 2D movies against the answers of individuals who had not yet watched the movie. In Table  
167 3, we show the estimated results for five questions, where the outcome is the probability that  
168 the respondent “agrees completely” with a particular statement. Among the control group,  
169 the share of people who agreed completely with the statements varied from 50% and 86%.  
170 As with the observed actions, we find significant differences between the treatment groups  
171 and the control groups in their level of agreement with most statements. However, we only  
172 detect a statistically significant difference between the effect of 2D and VR treatments for  
173 one outcome (Column 4).

Table 2: Coefficients on VR for WhatsApp sample

	All		Only control	
	(1)	(2)	(3)	(4)
VR	0.0450*	0.0438*	0.0552	0.0262
	(0.0262)	(0.0259)	(0.0466)	(0.0477)
Controls	N	Y	N	Y
R2	0.00790	0.119	0.0115	0.269
Mean 2D	0.0455	0.0455	0.0448	0.0448
N	364	364	127	127

Obs: \* 0.10 \*\* 0.05 \*\*\* 0.01 significance levels. This table shows the results for OLS regressions of the probability of clicking on the personalized link on the VR movie. The sample is composed of individuals who shared their WhatsApp information with the organization that produced the movie (Interfaith Rainforest Initiative). Three months after the experiment, the research team sent messages on the organization’s behalf asking them to access and share a weblink about the movie. Columns 1 and 2 use all individuals who shared their WhatsApp number, regardless of whether they were in the control group or one of the treatment groups of the experiment. Columns 3 and 4 only use the individuals in the control group that shared their WhatsApp number. Columns 2 and 4 control for demographic characteristics (age, sex, religion, and education). In all specifications, inference is done by computing robust (White) standard errors.

174 In Column 1, we show that watching the movie in either format did not affect partici-  
175 pants’ stated belief that “the Brazilian government has the obligation to protect the Amazon  
176 Forest”. Similarly, a null effect is found in Column 5, which shows the impact of the inter-  
177 vention on the stated belief that whether “NGOs play an important role in raising awareness  
178 on forest conservation”. The level of baseline agreement with these statements was 78% and  
179 66%.

180 Columns 2, 3, and 4 show positive effects of the treatment on the probability of agreeing  
181 with the statements. Watching the movie increased the probability that participants agree  
182 completely that “rich nations should support Brazil financially in preserving the Amazon  
183 Forest” by 12 (2D) and 15 (VR) percentage points, with no significant difference between  
184 the two coefficients (Column 2). This outcome had the lowest baseline level of complete  
185 agreement (50%). The movie also increased the perception of Indigenous people as protectors  
186 of the forest, with both movie versions increasing the probability that participants agree  
187 entirely with this view by 11 p.p. (Column 3) from a baseline of 63%. This strong effect  
188 probably reflects the prominence of Indigenous characters in display in the movie.

189 Finally, only the VR version made people more likely to disagree entirely with the state-  
190 ment that “forest conservation imposes poverty on the local populations”, with an effect of  
191 7 p.p. (Column 4). This is the only outcome for which the difference between the 2D and  
192 VR treatment is statistically significant, as seen in the reported p-values of the equality test  
193 between the two coefficients in Table 3. The difference is still significant after including demo-  
194 graphic controls in the regression (Panel B) and after the inclusion of enumerator and survey

195 day fixed effects (Panel C). This outcome is also the one with the highest level of baseline  
 196 consensus, with 86% of participants in the control group completely disagreeing with it.

Table 3: Treatment effects estimation on stated environmental attitudes

	Conservation obligation	International financial aid	Indigenous people	Conservation vs poverty trade-off	Positive view on NGOs
<b>Panel A: no controls</b>					
	(1)	(2)	(3)	(4)	(5)
2D	-0.0262 (0.0428)	0.117** (0.0496)	0.105** (0.0465)	-0.00132 (0.0358)	0.0397 (0.0470)
VR	0.00463 (0.0402)	0.153*** (0.0473)	0.111** (0.0447)	0.0654** (0.0308)	0.0415 (0.0452)
R2	0.000996	0.0181	0.0126	0.00915	0.00172
p-value $\beta^{VR} = \beta^{2D}$	0.466	0.454	0.897	0.0374	0.968
<b>Panel B: + controls</b>					
	(1)	(2)	(3)	(4)	(5)
2D	-0.0147 (0.0433)	0.110** (0.0498)	0.0949** (0.0459)	-0.00267 (0.0354)	0.0352 (0.0470)
VR	0.00686 (0.0403)	0.144*** (0.0476)	0.102** (0.0442)	0.0615** (0.0308)	0.0408 (0.0451)
R2	0.0329	0.0304	0.0554	0.0419	0.0342
p-value $\beta^{VR} = \beta^{2D}$	0.611	0.482	0.876	0.0451	0.903
<b>Panel C: + enumerator and survey day fixed effects</b>					
	(1)	(2)	(3)	(4)	(5)
2D	-0.0275 (0.0413)	0.0952* (0.0487)	0.0867* (0.0452)	-0.00603 (0.0358)	0.0293 (0.0448)
VR	0.00887 (0.0392)	0.150*** (0.0453)	0.109*** (0.0418)	0.0590* (0.0305)	0.0508 (0.0425)
R2	0.121	0.130	0.149	0.0613	0.138
p-value $\beta^{VR} = \beta^{2D}$	0.372	0.229	0.597	0.0458	0.618
N	617	617	617	617	617
Mean control	0.776	0.500	0.629	0.852	0.657

Obs: \* 0.10 \*\* 0.05 \*\*\* 0.01 significance levels. This table shows the results for OLS regressions of the outcomes, described in columns on the treatment. The outcomes are the probability that participants agree completely with a statement read to them, except for the outcome in Column 4, which measures the probability that participants *disagree* completely with the statement. Participants were asked to give their degree of agreement, ranging from disagree completely to agree completely, plus an option not to answer the question. The statements for Columns 1 to 5 were “The Brazilian government has the obligation to protect the Amazon Forest”, “rich nations should support Brazil financially in preserving the Amazon Forest”, “The Indigenous Peoples are protectors of the Amazon forest”, “Preserving the Amazon forest keeps the local population in poverty”, and “NGOs are essential to raise awareness of the public about Amazon conservation.” The two treatment groups refer to people who were randomly selected to watch the movie *Amazônia Viva* and were interviewed after watching the movie. These participants were randomly selected to watch one of the two versions of the movie (2D or VR format). The control group comprises participants randomly assigned to be interviewed before watching the movie. Panel A shows the results for the simple specification without any controls. Panel B controls for dummies of religion (Catholic, evangelical, atheist, no religion, others), dummies of highest attained education level (incomplete basic education, complete basic education, incomplete higher education, complete higher education, graduate studies), and age in years. Panel C shows the specification for the same set of controls, plus dummies for the enumerator who conducted the interview. In all specifications, inference is done by computing robust (White) standard errors.



## 197 Discussion

198 Preferences are usually considered as given parameters by social scientists. However, govern-  
199 ments and private organizations frequently undertake initiatives to shape people’s opinions  
200 and affect their preferences. Particularly in environmental settings, increasing socially re-  
201 sponsible behavior can improve environmental outcomes and social welfare by mitigating  
202 market failures caused by environmental externalities ([1]). Awareness-raising campaigns  
203 that message households or individuals urging them to take pro-conservation behaviors have  
204 been shown to be cost-effective and elicit reductions in electricity consumption ([2]) and wa-  
205 ter consumption ([3]). Moreover, the “nudge” literature has provided evidence of how cheap  
206 interventions may elicit cost-effective treatment effects toward pro-social behavior ([4]).

207 It is worthwhile pondering about potential mechanisms behind the effects of a movie on  
208 people’s pro-environmental actions and attitudes. Messaging interventions can potentially  
209 affect people’s behavior by activating or strengthening values already held by information  
210 receivers or by shifting their beliefs through new information. Through the values channel,  
211 the intervention does not necessarily add information to the participants’ knowledge but  
212 awakens a latent set of ideas that encourage their immediate pro-social behaviors ([5]). The  
213 literature has documented that messaging interventions have the potential to activate people’s  
214 sense of identity and their pro-social values. Studies have shown that the use of images is  
215 particularly effective at activating people’s identity and leading to pro-social behavior ([6],  
216 [7]). Moreover, messages that appeal to social norms and environmental values seem to be  
217 more effective than messages that appeal to individuals’ self-interest and economic gain ([8]).

218 Besides the ability to activate people’s group identity and pro-social values, messaging can  
219 also change behavior by informing individuals about an important topic and changing their  
220 perceptions thereof. In our setting, informational interventions may alter people’s behavior by  
221 shifting their beliefs about the importance of environmental conservation. For example, the  
222 airing of documentaries about climate change and air pollution seems to affect the behavior  
223 of people who watched the movies regarding conservation ([9]) and self-protection ([10]). In  
224 a political context, Pons [11] provided evidence of how a few minutes of canvassing for a  
225 candidate increases the chances of voting for this candidate. Using videos and images is  
226 widely seen as a means to increase engagement and transmit information more effectively.  
227 For example, Baul *et al.* [12] show that videos boost the treatment effect of agricultural  
228 extension services in a developing country setting. Indeed, educational activities tend to rely  
229 heavily on videos and the newest communication technologies to convey information in a  
230 persuasive way, including with the use of Virtual Reality.

231 In this study, we expose participants to a messaging intervention consisting of a 10-minute  
232 video. Though it is not possible to precisely establish whether the mechanism behind the  
233 effects is the enticement of pro-social behavior or the provision of novel information, it is

234 more likely that the intervention is related to the activation of pro-social values. The reason  
235 is that the movie does not convey scientific facts, theories, or facts, but rather provides an  
236 immersive experience to viewers. Immersive experiences are believed to boost learning and  
237 potentially affect their perceptions and opinions about subjects. For example, schools or  
238 companies sometimes take students and collaborators on field trips to raise awareness about  
239 relevant issues. The possibility of providing an immersive experience is greatly expanded  
240 by technology, notably Virtual Reality (VR) technologies, which simulate an immersive ex-  
241 perience for viewers without displacing them physically to another context or locality. The  
242 increasing availability of VR enables scaling the participation of immersive experiences, which  
243 are otherwise too costly to be scaled on large populations.

244 One important potential application of Virtual Reality is to raise awareness of envi-  
245 ronmental issues and potentially affect people’s behaviors and beliefs about them. Virtual  
246 reality can be particularly appealing for organizations working on environmental topics be-  
247 cause environmental issues, such as forest conservation or climate change, can be perceived  
248 as distant or abstract to city dwellers. At the same time, in countries where most of the  
249 population lives in cities, urban dwellers have a considerable impact on conservation through  
250 their consumption behavior and electoral impact in shaping environmental policies. In a  
251 study with politicians from six Western countries, Pereira *et al.* [13] found that politicians  
252 displayed more interest in procuring scientific information about environmental topics when  
253 their constituents were more environmentally aware. At the same time, Angrist *et al.* [14]  
254 document that constituencies with more pro-environmental voters tend to vote for politicians  
255 with stronger pro-environmental views. Therefore, citizens’ attitudes toward conservation are  
256 highly consequential to environmental outcomes, regardless of their ability to directly engage  
257 in environmental damage.

258 The closest related study to ours is Nelson *et al.* [15], which shows that a Virtual Reality  
259 video about coral reefs in Indonesia displaying a negative message leads to more donations  
260 for coral reef conservation than 2D videos or a control group that did not watch any movie.  
261 In contrast to that study, our experiment focuses on a population that is geographically very  
262 far away from the epicenter of the environmental problem at hand. Moreover, our control  
263 group is directly comparable to the treatment group because all recruited participants agreed  
264 to complete the full cycle of watching a movie and being interviewed. Our video experiment  
265 elicited strong effects from participants, producing promising evidence for easily scalable  
266 interventions, such as showing a 10-minute video. However, the result suggests that the VR  
267 technology, despite its much richer experience, does not yield a uniquely large treatment  
268 effect, with cheaper platforms such as a 2D tablet performing almost just as well. The  
269 VR experience led to a longer-lasting engagement of participants with pro-environmental  
270 content but the additional effects of VR on behavior seem to be marginal relative to the 2D  
271 experience.

## 272 **Methods**

### 273 **Experimental Design**

274 The field experiment was conducted at the shopping mall Conjunto Nacional in Brasília,  
275 Brazil's capital city. The shopping mall is next to the city's largest bus terminal and receives  
276 clients from different socio-economic backgrounds. The shopping mall administration kindly  
277 agreed to reserve a space for the experiment's set-up. The research team used the space to  
278 create two small environments to diffuse the movie: one containing tablets to display the  
279 2D version of the movie and one with Virtual Reality headsets to diffuse the VR version.  
280 Any person walking past the experiment's location could not immediately see what was  
281 happening inside these environments, which were hidden from public view by a screen, so  
282 potential participants would not be aware of the technologies used for the movie diffusion.  
283 We disposed of four VR headsets and three tablets and could show the movie to seven people  
284 simultaneously. In rare occasions where there was high participation demand, this resource  
285 constraint was hit, but in all these instances, the participants waited a few minutes in line  
286 and could watch the movie.

287 The research team in the field consisted of nine enumerators hired by the Interfaith Rain-  
288 forest Initiative. One of the lead researchers participated in the first week of the experiment  
289 in the field, training the enumerators, setting up the environment, and conducting inter-  
290 views. At all times, six enumerators ran the experiment, with one being a supervisor to the  
291 others. The training happened on July 17<sup>th</sup> and 18<sup>th</sup>, 2023. On July 19<sup>th</sup>, 2023, the team  
292 ran pilots from 10 AM to 3 PM in the shopping mall, which helped enumerators get used to  
293 the questionnaire, spot mistakes in the text, and solve technical issues with the technologies.  
294 From then on, the data collection started, ending at 7 PM. For the next days, data collection  
295 happened until August 10<sup>th</sup>, 2023, except on Sundays, from 2 PM to 7 PM.

296 The enumerators wore a T-shirt indicating they were running a research project, and ban-  
297 ners around the experiment's site displayed the sponsoring organization's logo. Recruitment  
298 happened by approaching potential participants among the clients walking in the shopping  
299 mall, inviting them *to watch a movie about the Amazon Forest* produced by the UN-sponsored  
300 Interfaith Rainforest Initiative and *to answer a questionnaire*. They were instructed to offer  
301 a gift in exchange for their participation (an eco-bag or a water bottle provided by the In-  
302 terfaith Rainforest Initiative). They were advised not to mention that there was a Virtual  
303 Reality version of the movie. When a person accepted to participate in the research, the  
304 enumerator would accompany the person near the experiment's site and read the consent  
305 form. No person declined to continue after listening to the consent form.

306 The movie was produced and financed by the Interfaith Rainforest Initiative (IRI), a UN-  
307 sponsored project that is present in several tropical countries worldwide. The organization's  
308 main mission is to raise awareness about forest protection by leveraging religious networks. In

309 Brazil, IRI regularly invites religious leaders, such as evangelical pastors and Catholic priests,  
310 to participate in lecture series with leading experts in climate change and forest protection.  
311 The movie *Amazônia Viva* was produced to meet IRI’s goal of raising awareness for Amazon  
312 protection with an artistic lens. The movie does not contain a religious message, so IRI uses  
313 it to participate in various events and reach wide audiences, including non-religious ones.  
314 The movie lasts for almost 10 minutes. Its script consists of a trip to the Tapajós river,  
315 in the Brazilian Amazon Forest, guided by the indigenous leader Raquel Tupinambá, who  
316 highlights the biodiversity and beauty of the place. In one scene toward the end, we also see  
317 a scene of forest fire in a deforested area. The movie has two subtle references to religious  
318 themes: a one-time mention of the word “Creator” as the author of the natural beauties of  
319 the Amazon forest, and the final scene, in which the indigenous leader performs a prayer in  
320 the Tupy language.

321 The experiment has a control group and two treatment arms, as displayed in Figure 1.  
322 The control group consists of participants who are interviewed *before* watching the movie,  
323 but they also watch a movie later on. The two treatment arms are made of participants who  
324 are interviewed after watching either 2D or VR movies. Since the control group participants  
325 can also watch either 2D or VR movie, the randomization design splits participants into four  
326 different groups:

327 **Treatment 1** (30% probability): the participant watched the 2D version of the movie  
328 and is interviewed after that.

329 **Treatment 2** (30% probability): the participant watched the VR version of the movie  
330 and is interviewed after that.

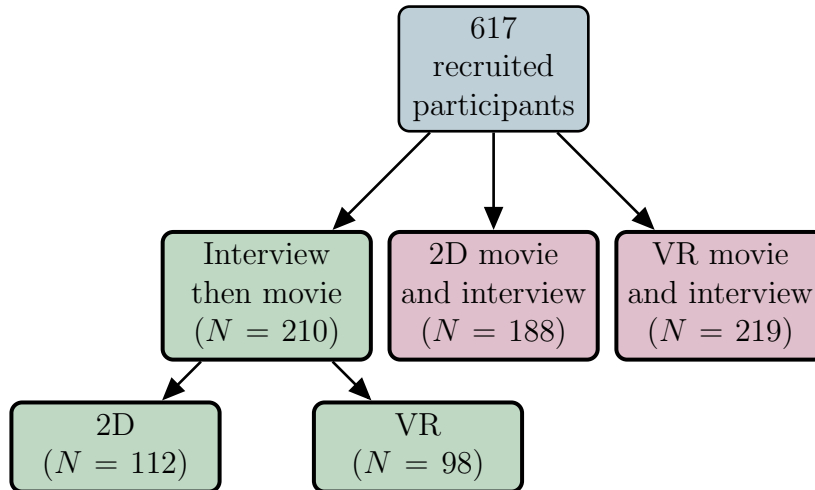
331 **Control 1** (15% probability): the participant is interviewed and then watches the 2D  
332 version of the movie.

333 **Control 2** (15% probability): the participant is interviewed and then watches the VR  
334 version of the movie.

335 Randomization was done independently for each new participant. There were two levels  
336 of randomization in this field experiment. The first one determined whether we collect  
337 the outcome variables from the participant *before* or *after* by showing them the movie (the  
338 intervention). The second level of randomization determined whether the participant watches  
339 the 2D or VR version of the movie. The participants in the control groups were given a chance  
340 to update their answers after watching the movie, an option that some of them took.

341 Figure 1 graphically represents the experimental design. The green boxes denote the  
342 control group, where participants were interviewed before watching a movie. The red boxes  
343 show the two treatment arms. Since the participants were randomized “in real time” as they  
344 arrived to the experiment, the realized share of participants does not match exactly the “ex  
345 ante” assignment probability set for the experiment.

Figure 1: Experimental design



## 346 Survey Design and Data Collection

347 The survey was designed using the software Qualtrics, and data was collected using the enu-  
348 merators' smartphones and tablets. Each new participant was randomized to the treatment  
349 or control arms according to a pre-specified probability coded into Qualtrics. The survey  
350 would start with a consent form, which was read aloud to participants. After giving their  
351 consent, enumerators collected a few demographic characteristics of participants: sex, age,  
352 religion, and education level. These questions were asked before showing the movie to all  
353 groups. At this point, the survey diverged between control and treatment groups. For control  
354 participants, enumerators would continue the interview and collect the outcome variables,  
355 whereas treatment participants were led to a location where they could watch the movie as-  
356 signed to them (2D or VR). Participants were informed about the type of movie only at this  
357 moment, and even enumerators did not know which movie the participant would watch until  
358 this moment. Participants were asked the outcome questions immediately after watching the  
359 movie.

360 Participants were recruited among the shoppers at Conjunto Nacional, one of the main  
361 shopping malls in Brasília. Enumerators were dressed in a T-shirt that indicated that they  
362 were part of a research group, with the logo of IRI, the sponsoring organization. There was  
363 a banner of the movie Amazônia Viva at the location of the experiment, with no indication  
364 about the VR component. The protocol for recruitment was to invite shoppers to watch a  
365 10-minute movie about the Amazon Forest and answer a few questions. Enumerators were  
366 instructed not to mention that the movie was available in a VR and 2D format.

367 The experiment and data collection always happened in the afternoon, starting at around  
368 1:30 PM until 7 PM, from July 19<sup>th</sup>, 2023 until August 9<sup>th</sup>, 2023, skipping Sundays (July  
369 23<sup>rd</sup> and July 30<sup>th</sup>). The shopping mall's administration reserved two different spaces for  
370 the experiment, which were used at different moments. The first space, on the floor of the

371 food court for the experiment, was used during the first week of the experiment (July 19<sup>th</sup>  
372 to July 25<sup>th</sup>), whereas the second space was in a corridor at a lower floor. In both spaces,  
373 the research team created two separate spaces for the VR and 2D participants. These spaces  
374 were visually hidden from other shoppers, so potential participants could not see the VR  
375 headsets or the tablets used in the 2D arms.

376 There are two types of outcome variables: self-reported attitudes toward environmental  
377 topics and concrete actions. The self-reported attitudes questions asked participants how  
378 much they agreed or disagreed with five statements. The available options were: “Entirely  
379 disagree”, “Moderately disagree”, “Neutral”, “Moderately agree”, and “Entirely agree”, plus  
380 an option not to give any opinion. The five statements were:

- 381 1. “The Brazilian government has the obligation to protect the Amazon Forest”,
- 382 2. “Rich nations should support Brazil financially in preserving the Amazon Forest”,
- 383 3. “The Indigenous Peoples are protectors of the Amazon forest”,
- 384 4. “Preserving the Amazon forest keeps the local population in poverty”, and
- 385 5. “NGOs are essential to raise awareness of the public about Amazon conservation.”

386 After collecting data about the state attitudes, enumerators invited participants to take  
387 some “actions”. The actions were (in order):

- 388 1. Enumerators explained the initiative “Amazônia de Pé”, a conservationist movement  
389 that proposed a law to make deforestation law more stringent in the Amazon. The  
390 enumerator then invited the participant to use their smartphone to enter a webpage  
391 containing information about the movement, by reading a QR code.
- 392 2. The enumerator asked the participant to share a post of the initiative “Amazônia de  
393 Pé” on the social media of their preference (Instagram, Twitter, Instagram).
- 394 3. The enumerator asked the participant to provide their WhatsApp number to share more  
395 information with them about the movie and other initiatives of Interfaith Rainforest  
396 Initiative.
- 397 4. The enumerator explained the humanitarian campaign “SOS Ianomâmis”, which col-  
398 lects funds for the Yanomami group in the Amazon Forest. The enumerator then  
399 asked the participant to make a financial donation for this initiative, through a secured  
400 website that they could access through a QR code.

401 For the control group participants who did not take some action before the movie, they  
402 were subsequently asked if they would like to take the action now that they had watched it.

403 However, they could not “undo” the action if they had already taken it.

404

## 405 Empirical Strategy

406 In the statistical analysis, we run the following regressions:

$$y_i = \alpha_0 + \alpha_1 Treatment_i + \gamma X_i + \epsilon_i \quad (1)$$

407 where  $y_i$  is an outcome of interest, and  $Treatment_i$  is a dummy variable indicating that the  
408 individual was part of one of the two treatment groups.  $X_i$  are demographic controls, and  
409 we run the regressions with and without them.  $\epsilon_i$  is a zero-mean error term. To perform  
410 inference on the coefficients, we compute White-robust standard errors.

411 To tease out the specific effect of the VR technology, we augment the specification in  
412 equation 1 to indicate whether the participant watched the 2D or VR version of the movie.

$$y_i = \beta_0 + \beta_1 Treatment_i^{2D} + \beta_2 Treatment_i^{VR} + \xi X_i + \epsilon_i \quad (2)$$

413

414 where  $Treatment_i^{2D}$  indicates that the treated individual watched the 2D movie,  $Treatment_i^{VR}$   
415 means that they watched the VR movie. The other variables are defined like in equation 1.  
416 We then test for the statistical difference between  $\beta_1$  and  $\beta_2$  using a t-test.

417 Although the participants in the control groups also varied in which movie they watched,  
418 they were unaware of this at the moment in which they answered the questionnaire and were  
419 lumped into a single control group.

420 Under the assumption of random treatment assignment, the coefficients  $\alpha_1$ , of Equation  
421 1 and  $\beta_1$ ,  $\beta_2$  of Equation 2 identify the Average Treatment Effects (ATE) of the intervention  
422 among the population of individuals willing to participate in the experiment. To test the  
423 quality of the randomization, we ran a balancing test using the socio-demographic variables  
424 as outcomes.

425 Several individuals in the control group refused to take the actions proposed to them by the  
426 enumerator, but were given the chance to take these actions after watching the movie. Some  
427 individuals took this opportunity. To test whether the VR version of the movie increased the  
428 chances that an individual updates their answers, we run the following regression:

$$y_i = \delta_0 + \delta_1 Control_i^{VR} + \mu X_i + u_i \quad (3)$$

429

430 where  $Control_i^{VR}$  indicates that the individual was in the control group, meaning that  
431 they were interviewed before watching the movie, and watched the VR version of the movie.  
432 This regression is only meant for the group of control groups individuals who refused to take  
433 the actions. We then assess whether the control individuals who watched the VR movie were  
434 more likely to take the action after the movie than control individuals who watched the 2D  
435 movie. Under randomization of individuals into the 2D or the VR movie, the coefficient  
436  $\delta_1$  captures the causal effect of making them change their minds because of the VR movie  
437 relative to the 2D movie, among individuals who initially refused to take the proposed action.

438

439 Finally, we also collected data from the participants who gave their WhatsApp numbers  
440 to the enumerators. Approximately three months after the experiment, the research team  
441 sent a message to each of these participants, inviting them to click on a link providing  
442 supplementary information about the movie they had watched. Although all links directed  
443 to the same web page, the links were individual and allowed the researchers to track how  
444 many times someone had clicked on the links. We estimate equation 3 using the sample of  
445 people who provided their Whatsapp number before receiving the treatment, to test whether  
446 the VR experience made them more likely to engage with environmental content three months  
447 after the experience, relative to the 2D movie. Moreover, we also run a regression including  
448 treatment individuals as follows:

$$y_i = \phi_0 + \phi_1 VR_i + \theta X_i + \nu_i \quad (4)$$

449

450 where  $VR_i$  lumps all individuals who watched the VR movie and provided their WhatsApp  
451 numbers, regardless of whether they were control or treatment groups. This specification has  
452 the benefit of including a larger sample of people as a population of interest, but it fails to  
453 meet the randomization assumptions needed for causal inference. The reason is that people  
454 who gave their Whatsapp numbers after watching the movie may have done so as a conse-  
455 quence of this treatment, and it is possible that the treatment effect of 2D or VR movies  
456 were different. Consequently, the population of 2D-movie watchers who gave their WhatsApp  
457 numbers does not an ideal counterfactual for the group of VR-movie watchers. Therefore,  
458 the results for this specification must be seen only as suggestive evidence and interpreted  
459 with caution.

460



## 461 **Ethics**

462 The experiment protocol was reviewed by the Institutional Review Board of Insper and  
463 approved on June 19<sup>th</sup>, 2023. The experiment did not present health risks to the participants  
464 and did not involve deceit. Consent was given verbally at the beginning of the interview.  
465 While reading the consent form, enumerators informed participants that the movie contained  
466 images recorded by drones, which might be uncomfortable to some viewers. No participant  
467 declined to participate after the consent form.

## 468 References

- 469 1. Bénabou, R. & Tirole, J. Individual and corporate social responsibility. *Economica* **77**,  
470 1–19 (2010).
- 471 2. Allcott, H. & Rogers, T. The short-run and long-run effects of behavioral interven-  
472 tions: Experimental evidence from energy conservation. *American Economic Review*  
473 **104**, 3003–3037 (2014).
- 474 3. Torres, M. M. J. & Carlsson, F. Direct and spillover effects of a social information  
475 campaign on residential water-savings. *Journal of Environmental Economics and Man-*  
476 *agement* **92**, 222–243 (2018).
- 477 4. Banerjee, S., Galizzi, M. M., John, P. & Mourato, S. Sustainable dietary choices im-  
478 proved by reflection before a nudge in an online experiment. *Nature Sustainability* **6**,  
479 1632–1642 (2023).
- 480 5. Van Zomeren, M., Spears, R. & Leach, C. W. Exploring psychological mechanisms  
481 of collective action: Does relevance of group identity influence how people cope with  
482 collective disadvantage? *British Journal of Social Psychology* **47**, 353–372 (2008).
- 483 6. Casas, A. & Williams, N. W. Images that matter: Online protests and the mobilizing  
484 role of pictures. *Political Research Quarterly* **72**, 360–375 (2019).
- 485 7. Gulliver, R., Chapman, C. M., Solly, K. N. & Schultz, T. Testing the impact of images  
486 in environmental campaigns. *Journal of Environmental Psychology* **71**, 101468 (2020).
- 487 8. Bolderdijk, J. W., Steg, L., Geller, E. S., Lehman, P. K. & Postmes, T. Comparing the  
488 effectiveness of monetary versus moral motives in environmental campaigning. *Nature*  
489 *climate change* **3**, 413–416 (2013).
- 490 9. Jacobsen, G. D. The Al Gore effect: an inconvenient truth and voluntary carbon offsets.  
491 *Journal of Environmental Economics and Management* **61**, 67–78 (2011).
- 492 10. Tu, M., Zhang, B., Xu, J. & Lu, F. Mass media, information and demand for en-  
493 vironmental quality: Evidence from the “Under the Dome”. *Journal of Development*  
494 *Economics* **143**, 102402 (2020).
- 495 11. Pons, V. Will a five-minute discussion change your mind? A countrywide experiment  
496 on voter choice in France. *American Economic Review* **108**, 1322–1363 (2018).
- 497 12. Baul, T., Karlan, D., Toyama, K. & Vasilaky, K. Improving smallholder agriculture via  
498 video-based group extension. *Journal of Development Economics*, 103267 (2024).
- 499 13. Pereira, M. M., Giger, N., Perez, M. D. & Axelsson, K. Encouraging Politicians to Act  
500 on Climate. A Field Experiment with Local Officials in Six Countries. *American Journal*  
501 *of Political Science* (2024).

- 502 14. Angrist, N., Winseck, K., Patrinos, H. A. & Zivin, J. G. Human capital and climate  
503 change. *Review of Economics and Statistics*, 1–28 (2024).
- 504 15. Nelson, K. M., Anggraini, E. & Schlüter, A. Virtual reality as a tool for environmental  
505 conservation and fundraising. *Plos one* **15**, e0223631 (2020).