

AUGMENTED REALITY TECHNOLOGY AS A TOOL FOR PROMOTING PRO- ENVIRONMENTAL BEHAVIOR AND ATTITUDES

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Augmented Reality technology as a tool for promoting pro-environmental behavior and attitudes

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ABSTRACT

We test whether augmented reality (AR) can serve as a fundraising tool by providing a more immersive way of communicating about environmental issues. In two incentivized studies, we exposed people to AR visualizations illustrating the consequences of plastic pollution, and measure the effect on participants' psychological distance, concern, intention to act and real pro-environmental behavior (donation to pro-environmental organizations). Results show evidence of heterogeneous effects depending on participants' self-reported pro-environmental attitudes and personal characteristics: following the intervention, individuals with low environmental engagement were likely to reduce their psychological distance, while the opposite happened for individuals engaged in sustainable practices. However, despite AR visualizations reduced the psychological distance of a subset of individuals, our experimental intervention did not increase donation levels. Taken together, our results raise concerns about the use of AR technologies in fundraising and highlight the need for personalised interventions that take into account the heterogeneity of target groups.

1. Introduction

Our world is facing an unprecedented environmental crisis. One of the fastest growing problems is plastic pollution, mainly caused by the overconsumption of single-use plastic products, especially due to personal protective equipment during the global COVID-19 pandemic (UNEP, 2021). However, besides constant warnings from leading global institutions, environmental policies often fail to achieve much-needed behavioral change. In the past decade, insights from behavioral economics and psychology have become widely recognised and applied for achieving more effective environmental policies (Bhargava and Loewenstein, 2015).

Nonprofit organizations play an important role in the fight towards the environmental sustainability: they communicate and educate on current issues, influence design and implementation of environmental policies, support relevant research and mobilise public support for environmental protection (Nisbet, 2018; Osuri, 2010). However, unlike companies, which generate their income through the sale of products and services, non-profits often rely on voluntary donations to carry out their activities. Therefore, understanding what triggers people's decision to donate is crucial to the success of any non-profits' initiative (Freeling and Connell, 2020; Verssimo, Campbell, Tollington, MacMillan and Smith, 2018).

On the other hand, communicating about environmental problems is challenging because of the lack of direct experiences. People are rarely directly exposed to environmental threats, and may therefore perceive them as remote and irrelevant risks (Carmi and Kimhi, 2015; Spence, Poortinga and Pidgeon, 2012). Psychological distance (Trope and Liberman, 2010) from environmental issues has been put forward by the literature as a possible explanation albeit with mixed evidence, for the citizens' relative lack of concern or action towards environmental crises (McDonald, Chai and

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Newell, 2015). However, while research suggests that personal experience of environmental threats is likely to bring environmental issues psychologically closer and increase perceptions of their risks (Akerlof, Maibach, Fitzgerald, Cedeno and Neuman, 2013; van der Linden, Maibach and Leiserowitz, 2015), exposing everyone to environmental threats would be complicated, lengthy, costly or even dangerous.

One idea to overcome this limitation would be to use immersive technologies such as augmented reality (AR) or virtual reality (VR), to communicate about environmental issues more vividly and to promote pro-environmental behaviors. Indeed, receiving information 'in-situ' plays an important role in cognitive processes such as learning and decision-making, and virtual technologies could be a suitable alternative to direct experiences to support 'situatedness' (Goel, Junglas, Ives and Johnson, 2012). By providing sensory-rich experiences, these types of technologies can create a sense of presence (Mol, 2019) and make users feel like they are directly experiencing environmental issues. However, to our knowledge, there is no study that examines the impact of AR on psychological distance from environmental threats.

To address this gap, we conducted two related studies. First, we designed an incentivized laboratory experiment to investigate whether AR visualizations can reduce psychological distance and promote pro-environmental behaviour. Specifically, we designed two controlled conditions. In our treatment condition, participants used an AR-based application demonstrating the consequences of plastic pollution on the most affected animals, while in our control condition, participants only read a message describing the consequences of plastic pollution on marine life. In both conditions, we experimentally observed individual pro-social behavior, by measuring voluntary donations to an environmental organisation using a well-established experimental paradigm¹. We then complemented donations choices with additional measures such as perceived psychological distance, environmental concern and attitudes. Second, we replicated the same experiment but in a more natural setting to test whether the same AR intervention 'in the field' is more effective than AR intervention in the context-free laboratory settings.

On the contrary to our expectations, the results show that the effect of AR on psychological distance is zero overall in both the laboratory and the field, but heterogeneous at the individual level. After the intervention, individuals with low environmental commitment feel psychologically closer to the problem of plastic pollution, while the opposite seems to be the case for individuals with high environmental commitment. When evaluating the impact of AR on donation behaviour, we find no evidence of a mediating effect between psychological distance and pro-environmental behaviour on donation levels.

Our paper suggests important practical implications for policy-makers. The experimental results raise awareness about the actual effectiveness of new technologies, such as AR, in promoting behavioral change. Recent work has highlighted the importance of evaluating heterogeneous effects when designing interventions (Bryan, Tipton and Yeager (2021)). Policy-makers should avoid "one-size-fit-all" solutions and be aware of possible unintended consequences affecting sub-group of the population before making decisions. We provide concrete guidelines for the use of AR in environmental interventions focused on fundraising, which can be useful for optimising the communication strategy of policy makers, non-profit organisations and environmentalists.

Second, the theoretical contribution of this research implies new insights into the use of novel technologies to promote pro-environmental behaviour using a donation game. This paper presents the first experimental investigation of the impact of AR technology on individuals' motivation to engage in pro-environmental behaviour by reducing their psychological distance from environmental issues. Third, the study provides a methodological example of using AR to bring context and field cues to laboratory experiments needed to evaluate policies and test individual decision-making.

The rest of the paper is organized as follows. Section 2 presents the relevant literature and hypotheses of the study. Section 3 describes the laboratory experiment. Section 4 describes the contextualized 'in the field' experiment and the relation with our first study. Section 5 discusses main results, draws on policy implications, and discloses the limitations of our experimental studies.

¹Pro-social behaviour refers to any costly individual actions that produce benefits to others. In the experimental literature, donations games are used to measure individuals' levels of prosociality (see Bicchieri and Dimant (2019) for a similar experimental setting as ours). Our experimental design and used paradigm differ substantially from those deployed in choice experiments. Our goal is to study the causal effect of AR on donation behavior.

2. Relevant literature and hypotheses

2.1. Psychological distance and risk perception of environmental issues

Despite urgent calls for action from global environmental institutions and researchers (UNEP, 2021), the behavioural changes needed to achieve sustainability are still in their infancy. Even when people are aware of environmental issues, translating their intentions into actual behaviour is no easy task (Kollmuss and Agyeman, 2002). Communicating environmental issues is challenging because of their abstract nature and the discrepancy between their causes and consequences. Indeed, we rarely experience environmental threats directly. For example, people living in the cities rarely observe the accumulation of plastic waste, as it is mostly found in remote locations - on exotic beaches or deep in the oceans. Research suggests that this lack of direct experience leads people to perceive environmental problems as temporally, socially or spatially distant events (Carmi and Kimhi, 2015; McDonald et al., 2015).

In social psychology literature, this phenomenon is called *psychological distance*. As explained by Construal- Level Theory (CLT), psychological distance is a subjective perception of how far an object or event is from the here and now - from oneself, from this place and time. When we do not experience something directly, but think about it, remember it or imagine it, we create abstract mental construals. If, on the other hand, an object is psychologically close to us, its mental construal becomes more concrete and we can think about it in more detail. This perceived psychological distance can be measured by four interdependent dimensions (temporal, spatial, social and hypothetical) that influence the estimation of when, where, for whom and whether an event occurs (Trope and Liberman, 2010).

Therefore, we can assume that those who do not have the chance to experience environmental threats, but view them as something distant in space and time, perceive them as less real or tangible events that are not likely to happen to them in the near future, or not at all, leading to environmental behaviour being seen as unnecessary adaptation. Indeed, some studies have shown that psychological distance can lead to environmental threats being perceived as abstract and not personally relevant risks (Carmi and Kimhi, 2015; Spence et al., 2012).

One study examined the relationship between participants' perceived psychological distance from climate change and their level of concern and willingness to act. The results suggest that reducing psychological distance may be a promising strategy to motivate pro-environmental behaviour, as it increases concern about the issue. In their study, concern about the environment was strongly related to intention to behave in an environmentally friendly way. Note, however, that actual behaviour was not measured (Spence et al., 2012). In addition, one study showed that people feel more responsible for environmental degradation at the local level and less responsible the distance increases (Uzzell, 2000).

It seems that communicators should focus on finding a strategy to minimise psychological distance, as this could lead to greater concern and perception of environmental risks, greener behaviour and greater support for environmental policies (Fox, McKnight, Sun, Maung and Crawfis, 2020; Spence et al., 2012; van der Linden et al., 2015). Furthermore, effective pro-environmental communication should help people better understand the consequences of their actions and make an issue relevant to the target group - their social group, place and time (Spence et al., 2012).

While concrete, direct experiences seem to be effective in raising people's awareness of risks and encouraging their environmental behaviour (Akerlof et al., 2013; van der Linden et al., 2015), this approach can be complicated, costly or even dangerous in the real world - taking citizens to remote beaches and underwater to observe the effects of environmental crises such as ocean acidification and plastic pollution could even be counterproductive. Nevertheless, it is important to change behaviour before more serious events occur.

One solution to overcome practical limitations and bring environmental problems psychologically closer could be the use of immersive media: content presented in an interactive and vivid format can translate abstract mental constructs into concrete ones, bring distant places closer, bring future events closer, and demonstrate the impact of environmental crises here and now, as suggested by Ahn, Fox, Dale and Avant (2015).

2.2. Immersive technologies and the sense of presence

People have always been impressed by the idea of being in one reality while simultaneously experiencing another. Technologies such as VR and AR have changed the way we consume content and experience the real and physical environment. While VR is fully immersive and "transports" the user into a virtual environment by blocking the view with a head-mounted display (HMD), AR uses smart glasses or screens to blend the real and the virtual - by overlaying reality with three-dimensional digital objects in real time, it creates the illusion that they really exist there (Azuma, 1997). The rapid development of new technologies, the internet and mobile devices has opened up new possibilities

for the immersive technology market, making it affordable and popular for the general public (Flavián, Ibáñez-Sánchez and Orús, 2019).

What distinguishes immersive media from other traditional media is its ability to produce highly vivid and interactive content that creates a sense of presence - the feeling of "being there" (Steuer, 1992). Presence is valued for its persuasive impact in a variety of disciplines, such as environmental and health communication (Bailey, Bailenson, Flora, Armel, Voelker and Reeves, 2015; Ahn, Hahm and Johnsen, 2019). While VR gives users the feeling of being present in an artificial environment mediated by technology, AR tends to create the illusion that digital objects are present in the users' real environment. If the virtual experience includes living beings, there is a chance of convincing users to see them as real and eliciting reactions such as fear or empathy. One of the first examples of emotional relationships with computers is Tamagotchi, a pocket device that acted as a virtual pet and got people to behave socially and form relationships (Fogg, 2003).

The compelling nature of immersive media makes it a suitable tool for environmental communication. If these sensory-rich immersive experiences could give users the feeling of directly experiencing the environmental threat and thus reduce the perceived psychological distance to environmental issues, immersive technologies could be proposed as Green IS - a technological solution that has the ability to orient users towards green behaviour (Melville, 2010).

2.3. Immersive experiments related to environmental engagement

Laboratory experiments are used in the discipline of environmental economics as a valid and reliable method to test theories in a controlled, context-free environment (Sturm and Weimann, 2006). However, since people rarely make decisions in context-free environments (Harrison and List, 2004), researchers came up with the idea of "bringing the field into the lab" and using virtual environments to provide participants with the necessary context to test more realistic decision-making (Innocenti, 2017; Mol, 2019).

The concept of using virtual experiments to test environmental policy was introduced by Fiore, Harrison, Hughes and Rutström (2009), who showed that virtual experiences can reduce judgement errors. In their study, participants watched virtual simulations of forest fires on a computer screen, whereupon their responses reflected beliefs that were closer to actual risks (Fiore et al., 2009). Several studies followed, examining the effects of low-immersive (computer screen) virtual environments on internal determinants of environmental behaviour and support for environmental policies (Bateman, Day, Jones and Jude, 2009; Olschewski, Bebi, Teich, Wissen Hayek and Grêt-Regamey, 2012; Matthews, Wilby and Murphy, 2017). Lately, researchers moved on to high-immersive virtual environments that create higher levels of immersion, such as AR or VR (Innocenti, 2017; Ahn, Bailenson and Park, 2014; Ahn, Bostick, Ogle, Nowak, McGillicuddy and Bailenson, 2016). In one study, for example, participants experienced cutting down a tree in virtual reality, whereupon they used 20Other studies suggest that immersive storytelling in VR can increase concern and risk perception about environmental issues (Chirico, Maiorano, Indovina, Milanese, Giordano, Alivernini, Iodice, Gallo, De Pietro, Lucidi, Botti, De Laurentiis and Giordano, 2020; Markowitz, Laha, Perone, Pea and Bailenson, 2018; Breves and Schramm, 2019), connect users more closely with nature (Ahn et al., 2016; Breves and Heber, 2020) and increase donations to environmental organisations for certain groups (Nelson, Anggraini and Schlüter, 2020).

A few studies have tested whether virtual reality is able to manipulate psychological distance from environmental issues (Ahn et al., 2016; Breves and Schramm, 2019; Breves and Heber, 2020; Markowitz et al., 2018). If computer simulations appear sufficiently "real" in a virtual environment, participants may treat them as if they really happened (Fiore et al., 2009). Consequently, the sense of spatial presence created in immersive virtual environments may minimise perceived psychological distance or increase risk perception for an environmental problem (Ahn et al., 2016; Breves and Schramm, 2021).

While VR technology tends to be represented in virtual experiments, three studies have experimentally investigated whether AR can guide people to adopt pro-environmental behaviours when grocery shopping. In these studies, participants used the application AR, which displayed additional information about products, such as their carbon footprint (Isley, Ketcham and Arent, 2017) Schaeffer et al., 2018; Joerss et al., 2021. The results suggest that AR can influence consumer behaviour and encourage shoppers to make more sustainable product choices (Isley et al., 2017).

To our knowledge, however, there is no study that experimentally examined the effectiveness of AR on its ability to manipulate psychological distance from environmental issues. Therefore, in this contribution we investigated (1) whether AR is able to manipulate psychological distance to an environmental issue and (2) whether the reduced psychological distance could stimulate pro-environmental behaviour at the individual level.

Immersive technologies can be used to virtually simulate experiences of environmental degradation. If the virtual experience seems sufficiently real, it can trigger a sense of presence or "being there" and thus serve as an alternative to

a direct experience. If the feeling of presence is achieved, we assume that such an intervention can reduce the perceived psychological distance. Based on the existing literature on psychological distance (PD) and previous experiments with immersive media, we therefore hypothesise the following:

- H1: AR intervention reduces psychological distance (PD)

Following previous literature on psychological distance to an environmental problem (climate change) and its association with intentions to act (Spence et al. (2012)), we hypothesise that reduced psychological distance can trigger pro-environmental behaviour, which we measure by voluntary donations to an environmental organisation. Therefore, we hypothesise:

- H2: Psychological distance mediates the effect of AR on pro-environmental behavior (voluntary donation to an environmental organization)

Considering that AR scenes of wildlife indoors may seem unrealistic (Buljat, 2022), we hypothesise that the same experience outdoors could seem more realistic and therefore be more effective in reducing psychological distance. We hypothesise the following:

- H3: AR intervention ‘in the field’ is more effective in reducing psychological distance (PD) than AR intervention in the laboratory.

For the same reason, we expect that an AR experience outdoor can trigger more pro-environmental behavior, which we measure by voluntary donations. We hypothesise:

- H4: AR intervention ‘in the field’ is more effective in promoting environmental behavior (voluntary donation to an environmental organization) than AR intervention in the laboratory.

3. Study 1 (AR interventions in the Lab)

We conducted an incentivized laboratory experiment to test the effects of AR on psychological distance and pro-environmental behaviour. We tested whether participants’ generosity towards environmental organisations responded to immersive AR experiences showing the consequences of plastic pollution for the five most endangered animals.

The experiment was composed of several parts to collect pre-experimental measures, individual choices in a donation game and self-reported attitudes towards plastic pollution. In the following, we describe the design and procedure of the experiment.

3.1. Methods

3.1.1. *Experimental procedures and treatments design*

We employed between-subject experimental design with two experimental conditions: a Control and the AR treatment. The sessions were individual (one participant per session) and took place in the faculty premises, in two empty large classrooms with identical settings: closed windows, all lights on and a single table and chair in the corner. Upon arrival at the lab, participants signed an informed consent form, were given a code which they later used for the lottery, and were randomly assigned to either the control group or the AR group.

After entering the room, each participant took a seat at the table with the tablet device. The experimenter read out the introductory text, which contained information about the experiment, the rights of the participants, data collection and incentives. Participants were informed that they would be taking part in a decision-making study. Participants were informed that they had an equal chance to win €300 in a lottery and that they could choose to donate a desired amount to an environmental organisation of their choice from the predefined list.

The first part of the experiment was the same for both treatments. Participants completed the pre-questionnaire, which collected demographic information, their environmental engagement, familiarity with technologies, previous donation experience and preferences for environmental organisations. Participants could choose to donate to one of the 12 well-known environmental organisations accepting donations through the website. The pre-questionnaire can be found in Appendix B.

After the participants had filled in the pre-questionnaire, the experimenter gave them a sheet with a short text about the harmful effects of plastic pollution and the call for donations, as one might encounter in real life. The experimenter

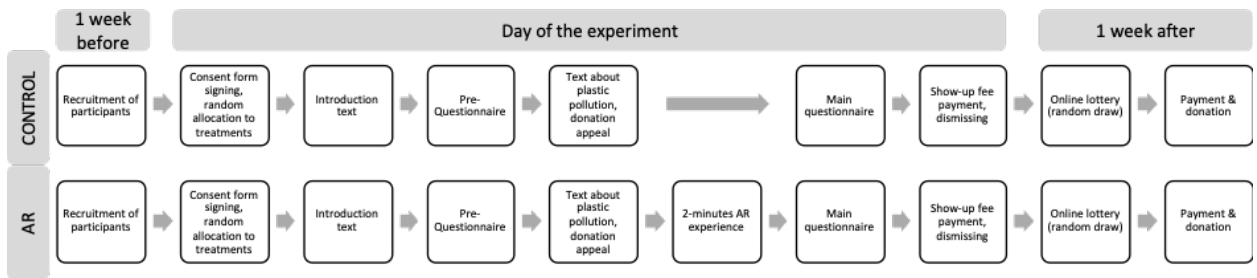
read the text aloud. After reading the text, participants in the control group moved on to the main questionnaire, while participants in the AR treatment group were asked to stand up and come to the centre of the room. The experimenter set up the mobile AR application Eco Animals on the tablet and explained to them how to use it. Participants were asked to interact with the application for 2 minutes and then continued with the main questionnaire.

The main questionnaire assessed psychological distance (Spence et al., 2012), environmental concern and donations in the Donation Game.

Participants in the AR treatment answered three additional questions: whether they felt the presence of animals in the room, whether they had similar experiences in the past, and whether the application brought them closer to the problem of plastic pollution. The questionnaires were created via Lime Survey (an online questionnaire service used by our university that ensures data protection and complies with European data protection regulations) and participants completed them in the internet browser using the same mobile device (Samsung Galaxy Tab S5e tablet). Details and questions of the main questionnaire can be found in Appendix B.

The sessions lasted about 15 minutes. After each session, participants were given a show-up fee and left the session. To ensure the credibility of the decision task, the draw was conducted via online video streaming a few days after the sessions. After the draw, the winners were paid, the money was donated to the environmental organisations selected by these participants, and proof of the donation was sent by email to all participants. The experimental procedure is summarised in Figure 1.

Figure 1: Experimental procedure



3.1.2. Stimuli

The mobile application Eco Animals was developed to our specifications by an external developer using the cross-platform game engine Unity. The application was installed on a Samsung Galaxy Tab S5e tablet running the Android operating system. The application illustrates the consequences of plastic pollution, presented in the AR format (see Figure 2). The visual content takes the form of the five animals most affected by plastic pollution: a sea turtle, a bird, a dolphin, a whale and a seal (Gall and Thompson, 2015). The scenes were inspired by real-life situations and anecdotal evidence.

After opening the application, users immediately see the image from the device camera. As soon as the system understands the environment and recognises the flat surface, a white rectangle appears on the bottom. Upon clicking on it, an animated three-dimensional projection of a life-size animal being strangled with disposable plastic waste appears and merges with the real environment in real time. The projection is interactive - its appearance reacts to the movements of the tablet.

The simplified dashboard has a few buttons: arrows (to move to another animal), zoom (to zoom in or out of an animal) and a rotate function (to rotate an animal). Participants in the AR treatment were briefly instructed on how to use the application and then asked to freely interact with it for two minutes. The video demonstration is available on request.

3.1.3. Experimental Measures

Pre-questionnaire

- **Environmental Engagement Score (EES).** An environmental engagement score (Cronbach's $\alpha = 0.71$) was obtained from the pre-questionnaire. The scale was created by calculating the mean of four questions related to

Figure 2: Examples of stimuli in the AR treatment



participants' self-reported current environmental engagement: Perception of being an environmentally conscious person; current level of environmental concern; current practises in purchasing eco-responsible products; recycling).

- **Past donation experiences and organisational preferences.** In the pre-questionnaire, we asked participants to indicate whether they had donated to an environmental organisation in the past, on a 5-point scale from "never" to "more than 10 times". We also asked participants which organisation they would donate money to if they had

the opportunity. Participants were able to choose from 12 well-known environmental organisations that mainly deal with plastic pollution and other related issues. Before adding an organisation to the list, we checked whether they accepted online donations.

- **Frequency of using related technologies.** To assess familiarity and frequency of use of related technological devices and services, we ask participants in the pre-questionnaire to indicate how often they use these technologies on a 5-point scale from "never" to "every day": smartphone; video games; AR; social networks; AR filters on social networks.
- **Other demographic variables.** During the pre-questionnaire, participants were additionally asked to provide the following information: age; gender; education (last degree and field of study); pet ownership (whether they own a pet); vacation preferences (what would be the perfect vacation for them, between sea, forest/mountain, countryside, city or home); glasses (whether they wear glasses); dietary options (whether they are vegetarian).

Main Questionnaire

- **Pro-environmental behaviour (*Donations*).** We measured actual donations using an incentivized game. Each participant was endowed with €300 and made a decision on how much to donate to a pro-environmental organization chosen from a comprehensive list. Participants were informed that decisions made were actually implemented according to the results of a lottery. Lotteries and raffles are often used in experimental economics research and public goods fundraising (Carpenter and Matthews, 2017). In particular, if a participant is randomly selected in the lottery, we implement his decision made in the donation game is implemented. Hence, the amount indicated in the game is donated to the organisation, while the remaining is given to the participant. Participants were given 10 donation levels, starting with €0 and ending with €300 (see answer options in Appendix B). Each participant had about a 1/30 chance of winning². The lottery results were announced publicly 1 week after the end of the experimental sessions.
- **Psychological distance (*PD*).** Following Spence et al. (2012), this measure combined four dimensions of psychological distance, namely: geographical distance, social distance, temporal distance and uncertainty. Geographical distance was assessed using two questions: One assessed the perception that plastic pollution affects one's local area; the other assessed the perception that plastic pollution affects distant areas. Social distance was also assessed with two questions: Participants were asked to rate whether plastic pollution was likely to affect mainly developing countries or people similar to them. Temporal distance was assessed with a single question asking participants when they think their country will feel the effects of plastic pollution. Uncertainty about plastic pollution was assessed with 5 questions about the perceived existence, severity, causes and effects of plastic pollution. The responses to the 7 items were combined into a single scale (Cronbach's $\alpha = 0.56$). The reliability of our composite measure increases when 2 items of the 7 considered are excluded ($\alpha = 0.6$).³ In our analyses, we use the latter measure, while the results of the former composite measure are used as robustness checks. The response options for all questions on psychological distance (with the exception of temporal distance) consisted of four- or five-point Likert scales. When necessary, responses were reversed so that higher scores represented a higher measure of psychological distance.
- **Concern about plastic pollution.** Following Spence et al. (2012), concern about plastic pollution was assessed using four similar questions: general concern about plastic pollution; concern about the personal impact of plastic pollution; concern about the impact of plastic pollution on society; and concern about the impact of plastic pollution on wildlife and animals. These four questions were combined to form a reliable scale of concern (Cronbach's $\alpha = 0.76$).
- **Preparedness to act.** We assessed participants' behavioural intentions to engage with the problem of plastic pollution through three questions about their consumption habits, recycling practises and policy support.
- **AR treatment intensity.** Only at the end of the AR treatment, we assess three other control measures in the main questionnaire: (1) Presence (we asked participants to rate on a 5-point scale (strongly agree - strongly disagree)

²Three lotteries were conducted: one for the control treatment and two more for the AR treatment.

³These items are uncertainty about the causes of and distance from pollution in developing countries

how much they felt the presence of animals in the room); (2) Perceived AR effect (we asked participants to rate on a 5-point scale (strongly agree - strongly disagree) the extent to which the experience at AR brought them closer to the problem of plastic pollution; (3) Previous experience (we asked participants to indicate whether they had had similar AR experience in the past). The first two measures were later combined into one variable called *treatment intensity*.

3.1.4. Sample and procedures

We recruited a total of 86 students for the experiment from our university's web-based Online Recruitment System for Economic Experiments (ORSEE), who were randomly divided into the control group (29) and the AR treatment group (57). Table A in Appendix A provides the demographic characteristics of the sample. The experiment was conducted in the Laboratory of Experimental Economics of our university⁴ in the period from June to November 2021. Several assistants were trained for the protocol and assisted during a total of 86 individual sessions over five days. Participants were incentivized with a €7 show-up fee. The recruitment and experimental design were approved by the Ethical Committee of our university under protocol #2021-030. All participants signed an informed consent form prior to participation.

3.2. Results

The main questionnaire assessed internal psychological determinants of environmental engagement related to plastic pollution, namely: four dimensions of psychological distance, concern about plastic pollution, behavioural intention and actual behaviour (donation to an environmental organisation).

3.2.1. The effect of AR on PD

According to H1, we expect shorter psychological distance in our treatment condition relative to the control. Figure 3 depicts the distribution of PD between control and treatment condition. We report no statistical difference between conditions for this variable (Wilcoxon rank sum test, $p=0.66$). Results are also confirmed by regression models (Table 1, models 1-2). The indicator variable *AR condition* is not significant in any model specification. The inclusion of *EES* highlights a significant negative correlation between environmental engagement and psychological distance. Controlling for other measures, such as age, gender or past use of AR does not affect our results.

Despite the absence of significant differences in PD levels between conditions, we find evidence of heterogeneous effects within the AR treatment when considering individual perception of AR. Models (3-6) in Table 1 regress PD on *Treatment intensity*, a self-reported measure of how AR scenes were perceived as realistic and brought closer to plastic pollution (see section 3.3.2). Across models, we include *EES* and its interaction with *Treatment intensity*, as well as demographics and past use of AR.

Results show no significant effect of *Treatment intensity* (model 3). Yet, the effect of this variable becomes significant when we account for individual controls (model 3) and its interaction with *EES* levels. Model 5 shows that for individuals that are not very environmentally engaged (low *EES*), a stronger intensity of AR scenes brought closer to the problem of plastic pollution (shorter PD). The opposite applies for highly engaged individuals (high *EES*). Results remain unchanged also when adding individual controls (model 6). Figure 4 depicts these results broken down by three categories of individuals with low (1), medium (2.5) and high levels of *EES* (5). Based on initial engagement with the environment, the experience of AR scenes may shorten or increase psychological distance.

3.2.2. Donation levels and mediation effect of PD

Following H2, we test whether AR has had an overall effect on donations in the Donation Game and whether and to what extent the effect is mediated by PD. Figure 5 shows the distribution of donations in the two experimental conditions. The average donation amount in the control group is slightly higher ($\bar{x}_C = 100$) than in the AR Treatment ($\bar{x}_{AR} = 93$). However, this difference in donation level is not statistically significant (Wilcoxon rank sum test, $p=0.92$).

When assessing the impact of *PD* on donations, the regression model estimates show no statistical relationship between these variables (table 2, models 1-2). These results are not surprising considering that AR has no impact on PD, as explained in the previous section. As expected, individuals' self-reported environmental engagement (*EES*) has a positive effect on donations (models 2 and 4).

We additionally run a mediation analysis to jointly estimate the effect of AR on PD and, in turn, the mediated effect of PD on donations.⁵ We run two analyses, one for the full sample and another for the AR sample only to account for the

⁴The name of the laboratory and its location have been removed to preserve anonymity

⁵We used the package *mediator* available from CRAN.

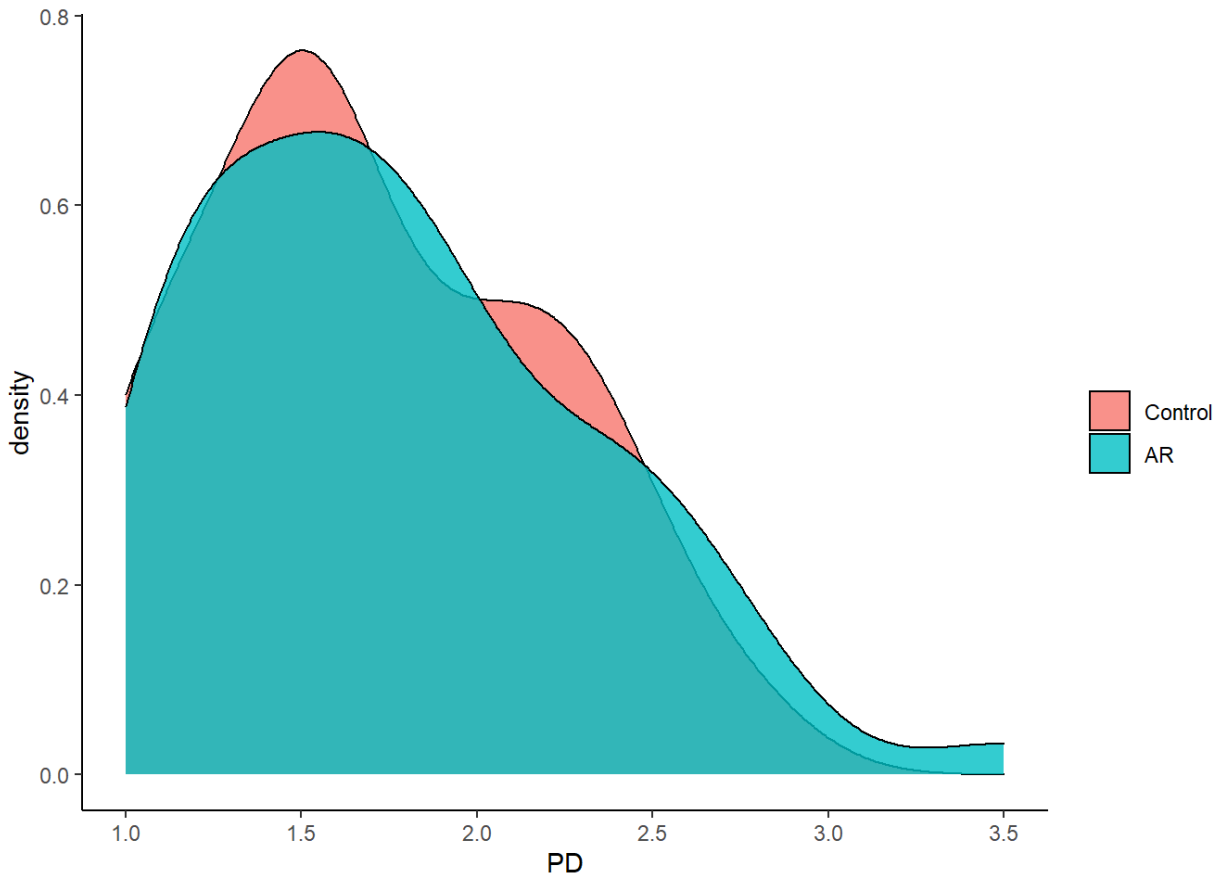


Figure 3: Distribution of Psychological Distance scores across conditions.

heterogeneous effect of *Treatment intensity* on *PD*. In all mediation models, we account for a set of controls previously included in our analyses, that is, demographics, past use of AR and EES. In both cases, we find no evidence of a mediating effect of *PD* on donations (Table 6). In particular, when using the whole sample, mediation analysis results show no effect of *AR* on *PD*, and hence absence of mediation (Indirect effect, $b=-0.34$, $p = 0.88$). When considering the AR sample, we find mild evidence of the effect of *Treatment Intensity* on *PD* (Direct effect, $b=30.24$, $p = 0.08$, Figure 6), consistently with section 4.1. Yet, there is no evidence in support of the mediation role of *PD* (Indirect effect, $b=-3.03$, $p = 0.42$). Put together, our analyses report not enough evidence in support of a mediation role of *PD*. Furthermore, neither the presence of AR nor the intensity of the treatment perceived by participants in the experiment affects donations.

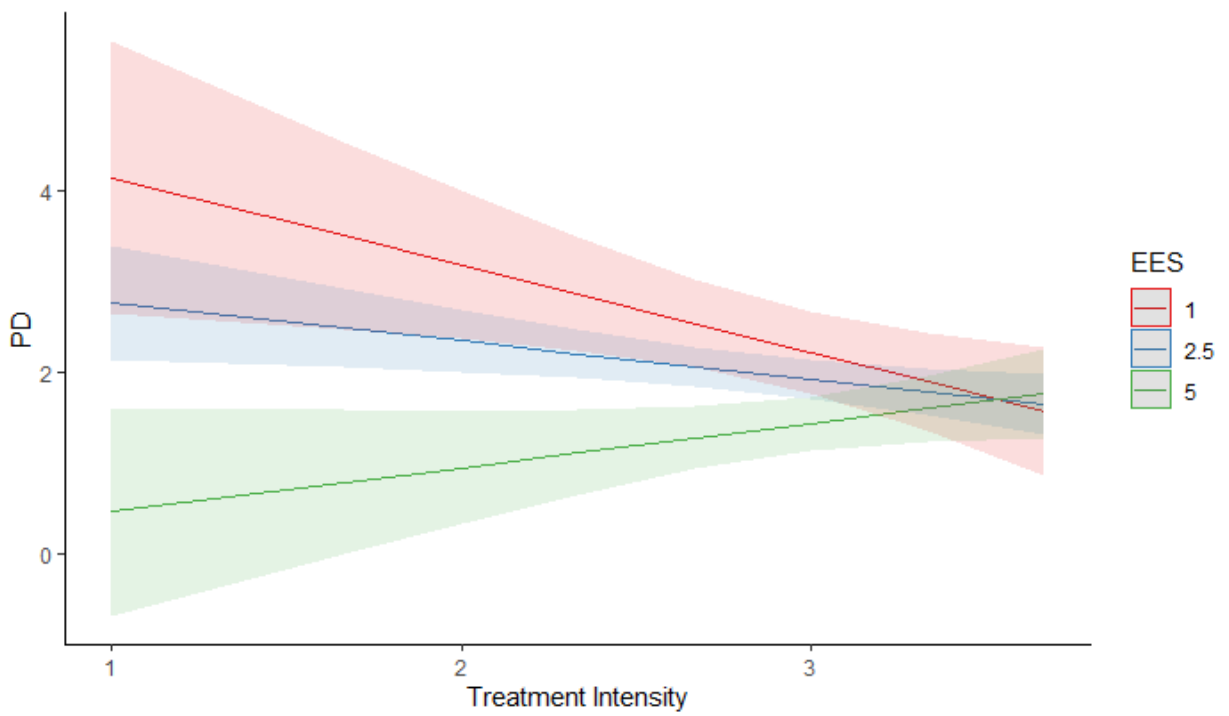


Figure 4: Predicted effect of *Treatment intensity* on Psychological Distance varying the level of EES.

Table 1
OLS regression models of PD

	Dependent variable: PD					
	Full sample		AR sample			
	(1)	(2)	(3)	(4)	(5)	(6)
AR	0.069 (0.121)	0.080 (0.125)				
EES		-0.168** (0.080)		-0.225** (0.106)	-1.283*** (0.478)	-1.355** (0.531)
Treatment Intensity * EES					0.363** (0.159)	0.377** (0.174)
Treatment Intensity			-0.151 (0.105)	-0.175 (0.111)	-1.328** (0.533)	-1.381** (0.567)
Age		-0.005 (0.011)		-0.004 (0.012)		-0.006 (0.011)
Male		-0.118 (0.143)		-0.052 (0.191)		-0.110 (0.185)
Use AR		0.139** (0.064)		0.230** (0.103)		0.174* (0.103)
Study level		0.108 (0.089)		0.083 (0.119)		0.084 (0.114)
Use smartphone		-0.832 (0.542)		-0.683 (0.578)		-0.946 (0.569)
Use video games		0.062 (0.058)		0.004 (0.083)		0.051 (0.083)
Use AR filters		-0.022 (0.049)		-0.034 (0.060)		-0.041 (0.058)
Donated before		-0.065 (0.075)		0.016 (0.098)		-0.015 (0.095)
Constant	1.637*** (0.210)	5.813** (2.722)	2.199*** (0.302)	5.880** (2.911)	6.394*** (1.596)	10.900*** (3.634)
Observations	86	86	57	57	57	57
R ²	0.004	0.172	0.036	0.243	0.201	0.315
Adjusted R ²	-0.008	0.062	0.019	0.079	0.155	0.147
Residual Std. Error	0.532 (df = 84)	0.513 (df = 75)	0.547 (df = 55)	0.530 (df = 46)	0.507 (df = 53)	0.510 (df = 45)
F Statistic	0.328 (df = 1; 84)	1.558 (df = 10; 75)	2.079 (df = 1; 55)	1.480 (df = 10; 46)	4.434*** (df = 3; 53)	1.881* (df = 11; 45)

Note:

*p<0.1; **p<0.05; ***p<0.01

Table 2
OLS regression models of *Donations*.

	<i>Dependent variable: Donations</i>			
	Full sample		AR sample	
	(1)	(2)	(3)	(4)
PD	-10.384 (16.289)	4.382 (17.604)	2.999 (18.385)	26.542 (19.577)
EES		26.545** (12.500)		22.854 (15.098)
Age		0.079 (1.621)		0.254 (1.587)
Gender		-8.640 (21.128)		-21.969 (25.881)
Use AR		-12.601 (10.084)		-34.446** (14.242)
Study level		-19.464 (13.689)		-30.829* (16.136)
Use smartphone		-29.318 (84.155)		-25.432 (79.691)
Use video games		6.688 (8.898)		9.162 (10.899)
Use AR filters		-6.851 (7.329)		-1.249 (8.244)
Donated before		-0.534 (11.513)		0.567 (13.076)
Constant	113.551*** (29.814)	242.365 (427.610)	87.655** (34.170)	259.661 (413.827)
Observations	86	86	57	57
R ²	0.005	0.136	0.0005	0.245
Adjusted R ²	-0.007	0.021	-0.018	0.080
Residual Std. Error	79.539 (df = 84)	78.430 (df = 75)	75.923 (df = 55)	72.177 (df = 46)
F Statistic	0.406 (df = 1; 84)	1.181 (df = 10; 75)	0.027 (df = 1; 55)	1.489 (df = 10; 46)

Note:

*p<0.1; **p<0.05; ***p<0.01

AR for promoting pro-environmental behavior and attitudes

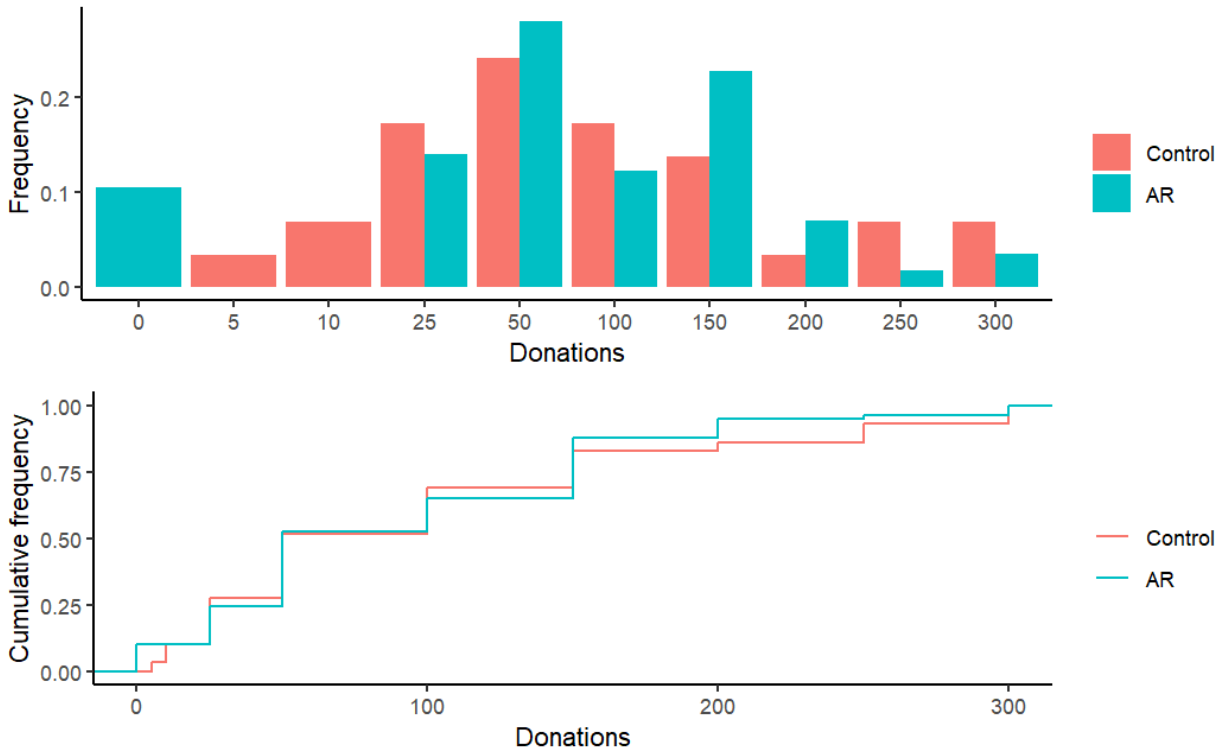


Figure 5: Donation levels by experimental condition.

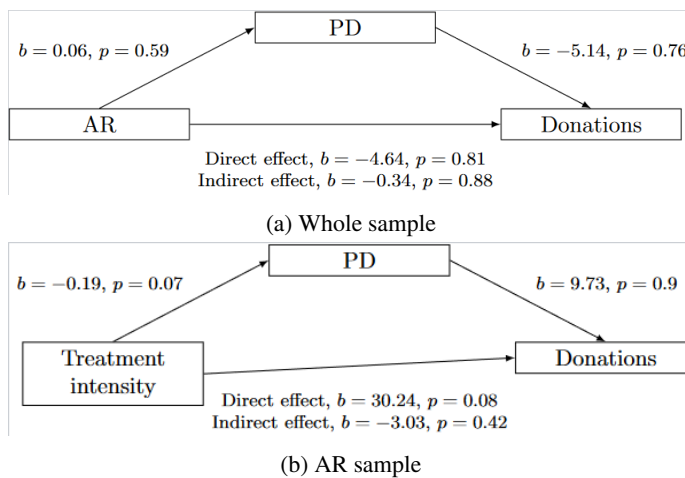


Figure 6: Mediation analysis results: a) for the whole sample; b) for the AR sample only. In the whole sample, *AR* is a dummy variable indicating the experimental condition. *Treatment intensity* is a continuous variable (see section 3.2.2)

3.2.3. Self-reported measures of concern and preparedness to act

We examine the impact of AR intervention on self-reported measures of concern about plastic pollution and preparedness to act. Preparedness to act consists of three questions about participants' plastic consumption habits, recycling practises and policy support. While AR scenes may increase concern, overall we find no difference in participants' preparedness to act (Figure 7-A; Wilcoxon rank sum test, $p = 0.63$). There are also no significant changes

between conditions when looking at the individual items (Figure A in the Appendix; Wilcoxon rank sum test, all results insignificant).

Similarly, we find no overall change in individuals' preparedness to act (Figure 7-B, Wilcoxon rank sum test, $p = 0.13$). Among the items composing our measure of preparedness, individuals' intention to support policy in favor of reducing plastic pollution slightly decreased upon AR interventions (Figure B in the Appendix; Wilcoxon rank sum test, $p = 0.03$). All other items are statistically similar across conditions.

4. Study 2 (AR interventions 'in the field'): Results validation

The results of a qualitative study assessing the feedback on the design and performance of AR experiences indicated that the lack of visual fidelity could be a barrier to the effectiveness of AR interventions (Buljat, 2022). Participants stated that it was unusual for them to see sea animals on the floor of the classroom. Therefore, it is reasonable to assume that the overall impression of a AR experience depends on its visual fidelity and the context in which AR intervention is experienced. To address this issue, we decided to switch from the context-free laboratory setting to a more natural context and repeat the experiment from Study 1 on the beach, where the AR experience might appear more natural and realistic. Therefore, in Study 2 we investigate whether the results observed in the *AR treatment* of Study 1 can be transferred to a more realistic context.⁶

4.1. Methods and Sample

The experiment was conducted at the natural beach of the small town at the south of France⁷ in late September 2022. The protocol was the same as the Study 1 conducted in the laboratory (see Figures F, G for the experimental setup).

The experiment lasted two full days. An experimenter and two protocol-trained assistants guided participants in 73 individual sessions. First, the participants came to the registration desk and signed a consent form. Then they sat down at the table and filled out a pre-questionnaire on a tablet. After completing the pre-questionnaire, they were asked to stand up and walk to a nearby sandy beach (15 m away) where the experimenter explained them how to use the AR application on a tablet and asked them to interact with it for 2 minutes. After the treatment, the participants sat down again at the same table where they filled in the main questionnaire. Before they left, we thanked them for participating and gave them the show-up fee.

We recruited a total of 73 subjects from the same population as in Study 1. Recruitment was done through our university's web-based online recruitment system (ORSEE) and we ensured that subjects had not previously participated in a similar experiment. See Table A in Appendix A for the demographic characteristics of the sample.

We collected the same independent and control variables as in the Study 1. The validity of our compound measures is comparable to our previous study (*PD* - Cronbach's $\alpha = 0.45$, *EES* - Cronbach's $\alpha = 0.71$).

4.2. Results

We first investigate whether *PD* levels in the field differ from those measured in the laboratory. Results from model 1 in Table 3 report no statistical difference between field and laboratory measures ($b = 0.025$, $p = 0.77$). The association between *EES* and *PD* remains negative as in Study 1. When using *Treatment Intensity*, results from model 2 show a negative association between *Treatment Intensity* and *PD* as seen in Study 1 ($b = -0.883$, $p = 0.002$), and such an effect is heterogeneous depending on subjects' level of environmental concern ($b = 0.228$, $p = 0.005$). These results hold even after the inclusion of our controls (model 3).

When passing on the analysis of Donation levels, we report no statistical difference between field and laboratory ($b = -4.602$, $p = 0.751$, model 4). Similarly, *Treatment Intensity* has no effect on Donations ($b = 10.471$, $p = 0.309$).

Overall, Study 2 replicates results seen in Study 1. *PD* levels do not differ between laboratory and field environment under the presence of AR. When using *Treatment Intensity* as main predictor, we still find heterogeneous effect based on subjects' environmental engagement (*EES*). Donation levels do not differ across conditions and seem not to be affected by one's perception of AR.

⁶This study was pre-registered at https://aspredicted.org/X16_Z86

⁷The exact location of the beach has been removed to preserve anonymity.

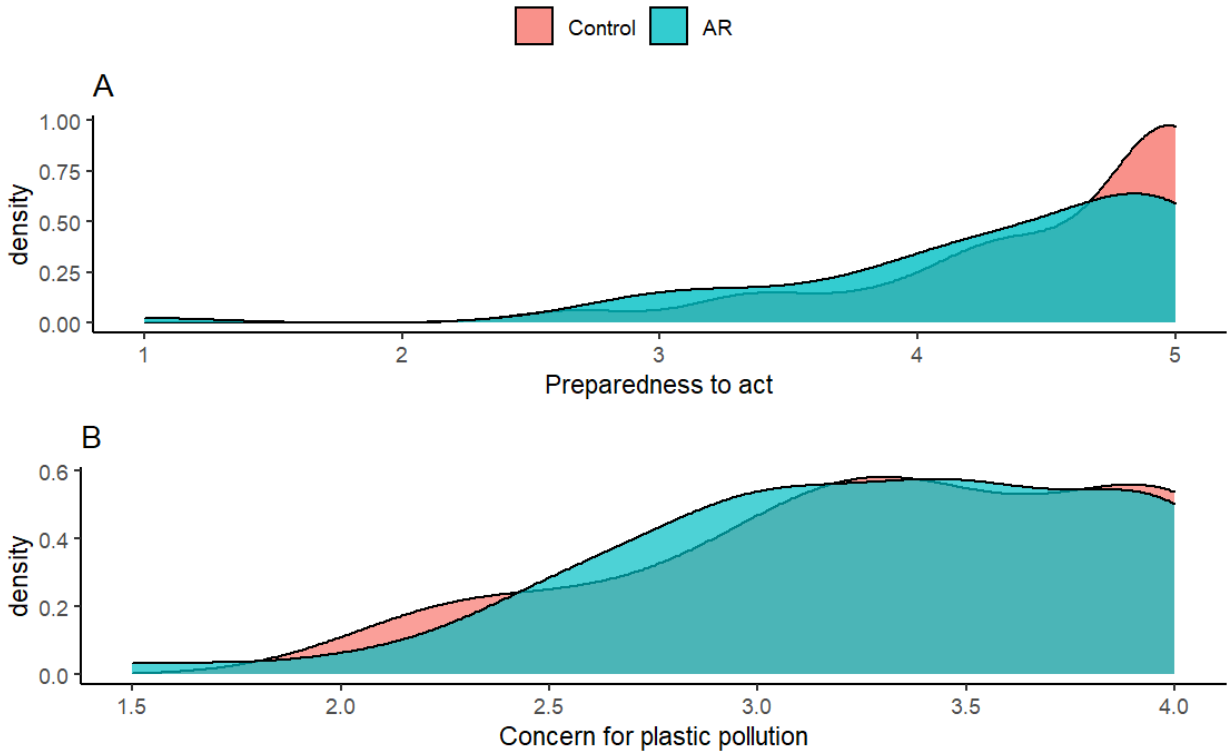


Figure 7: Distribution of A - preparedness to act, B - Concern for plastic pollution.

5. Discussion and Concluding Remarks

In this paper, we conducted two experimental studies, namely a laboratory and a more contextualized or ‘in the field’ experiment, to test how short AR experience illustrating the consequences of plastic pollution affect pro-environmental behaviour (donating to an environmental organisation). We also investigated whether the same AR experience is able to influence some internal psychological factors that are important for environmental engagement, such as psychological distance, concern and behavioural intentions.

Although we expected that AR interventions, and especially those experienced in a realistic setting, would decrease psychological distance and increase pro-environmental behaviour, we observed this effect only in a small group of participants. The results suggest that although participants stated that our intervention brought them closer to the problem of plastic pollution ($M\ 3,9/5$), there is no "one size fits all" solution.

Communicating about environmental issues via AR is likely to have a heterogeneous effect depending on the personal characteristics of the individual: people who are already familiar with AR and already adopt sustainable practises (recycle waste, consume environmentally friendly products, etc.) may "backfire" to this type of intervention and, in turn, increase their psychological distance. In contrast, communicating via AR might work better for people with low environmental engagement and no previous experience with AR, as they are likely to decrease their psychological distance to an environmental threat after such an intervention. A similar observation was made in a recent study: In an online experiment, participants who had previously shown lower environmental attitudes indicated a stronger intention to change their future environmental behaviour after watching an environmentally friendly video, compared to those who had not been exposed to it (Moore and Yang, 2019).

There are several possible explanations for these results. First, we can conclude that a "scenario rejection" (Fiore et al., 2009) can occur when a virtual intervention does not match an observer’s mental expectations. Indeed, our stimuli and context of use (seeing sea animals in the classroom) may not have been strong enough to influence all subjects, especially those already familiar with and regularly using the AR technology. The passive nature and questionable visual fidelity of the 3D models may have reduced the perception of the realism of the AR scenes. Secondly, there

Table 3OLS regression models of *PD* and *Donations* using data from Study 1 (AR treatment) and Study 2 (AR in the field).

	<i>Dependent variable:</i>				
	<i>PD</i>			<i>Donations</i>	
	(1)	(2)	(3)	(4)	(5)
Field	0.025 (0.085)			-4.602 (14.464)	
Treatment Intensity		-0.883*** (0.287)	-0.899*** (0.286)		10.471 (10.245)
PD				-15.311 (15.614)	-13.039 (15.724)
EES	-0.302*** (0.058)	-0.904*** (0.233)	-0.930*** (0.234)	31.393*** (10.888)	29.580*** (10.900)
Age	-0.001 (0.006)		-0.001 (0.006)	3.180*** (0.994)	3.179*** (0.978)
Male	-0.061 (0.104)		-0.027 (0.101)	13.252 (17.806)	12.299 (17.717)
Use AR	0.119** (0.059)		0.126** (0.057)	-5.846 (10.145)	-7.371 (10.213)
Study levels	-0.022 (0.059)		-0.007 (0.055)	-13.489 (10.006)	-12.294 (9.707)
Use smartphone	-0.915*** (0.334)		-0.878*** (0.323)	-20.635 (58.577)	-25.140 (58.511)
Use video games	0.015 (0.044)		-0.006 (0.043)	1.460 (7.529)	2.675 (7.565)
Use AR filters	-0.045 (0.037)		-0.044 (0.036)	-11.571* (6.401)	-12.343* (6.424)
Donated before	0.034 (0.050)		0.026 (0.048)	-0.527 (8.535)	-1.487 (8.480)
Treatment Intensity * EES		0.228*** (0.081)	0.233*** (0.082)		
Constant	7.267*** (1.714)	5.143*** (0.808)	9.545*** (1.824)	132.924 (313.289)	115.989 (309.818)
Observations	130	130	130	130	130
R ²	0.275	0.255	0.337	0.296	0.302
Adjusted R ²	0.214	0.238	0.275	0.231	0.237
Residual Std. Error	0.456 (df = 119)	0.449 (df = 126)	0.438 (df = 118)	77.727 (df = 118)	77.418 (df = 118)
F Statistic	4.516*** (df = 10; 119)	14.401*** (df = 3; 126)	5.446*** (df = 11; 118)	4.521*** (df = 11; 118)	4.643*** (df = 11; 118)

Note:

*p<0.1; **p<0.05; ***p<0.01

is a possibility that people with high environmental engagement may resist new technologies due to concerns about energy consumption (DataQuest, 2022). Finally, recent research highlights the need to consider the heterogeneity of target groups when applying insights from behavioural science (Bryan et al., 2021). Indeed, such behaviour change interventions, so-called nudges, can sometimes be counterproductive for certain groups. In such situations, it may be time to consider more targeted or personalised interventions (Sunstein, 2022).

Moreover, we note that a decrease in PD does not necessarily lead to an increase in donations, at least in the case of plastic pollution. First, it could be that our PD scale (Spence et al., 2012) is not entirely reliable for measuring psychological distance in this context (Cronbach's $\alpha = 0.6$). Secondly, it could also be that people do not trust environmental organisations and therefore, although they are concerned about the problem, they decide not to donate money. However, it seems that, as expected, those who report a high level of environmental engagement are also likely to donate more to environmental organisations.

Based on these findings, we suggest that AR interventions should be targeted at people with low environmental engagement and AR "newcomers" (people with no previous experience of AR). Influencing environmental engagement in other areas (recycling and consumption) may also have an impact on donation behaviour.

This research has some limitations, first of all the small sample. In addition, we did not take into account participants' risk preferences and opinions on the AR technology, which could explain the heterogeneous effects of the AR intervention. Therefore, in the future, we should add more observations for both AR and the control group and measure additional variables. Furthermore, this experiment only tests the effects of the AR experience on immediate behaviour. Future studies should examine the effects on long-term behaviour.

Also, the AR experience may have been too short and not interactive enough to make an impact. We should work on improving the AR experience, making it more engaging and longer. Since, according to our results, creating immersion and a sense of presence seems to be a promising way forward, environmental communicators could consider AR glasses, which certainly offer more immersive experiences than mobile AR. However, as this has not been empirically tested, we suggest comparing different types of AR hardware: Mobile AR and AR glasses.

Future steps should also include different behavioural interventions (e.g. recycling plastic waste), different samples (e.g. older population or youth) or different treatments (e.g. photo or video). However, when comparing AR with photo or video, there is a methodological challenge to overcome: Since each AR experience is unique and depends on the dynamics and movements of a user, it can be difficult to create a comparable screen capture.

One of the limitations of our experimental design is also the short time span between the treatment and the measurement of the behaviour. This is because environmental behaviour is complex and it may be unrealistic to expect it to change after a 2-minute intervention. Further studies should include longitudinal trials with more than one behavioural intervention.

However, the results of this investigation can serve as a basis for future studies measuring the effects of AR on pro-environmental behaviour, which could be useful in a similar context (e.g. by simulating future or distant events to reduce psychological distance and induce behavioural change).

This research makes an important contribution to academic research and practice. This was the first attempt to measure the effects of AR simulations on pro-environmental attitudes and behaviours, so these results pave the way for further research. We assume that if we are able to achieve a high level of presence with AR experiences in a laboratory, this could be a way to bridge the methodological gap between laboratory and field experiments by providing natural cues in context-free laboratory settings.

In addition, this contribution can serve as a guide for environmental policy makers and communicators using AR in their pro-environment campaigns. For example, a non-profit organisation can set up a spatial AR screen on the beach to warn about the harmful consequences of improper waste disposal, and policy makers can run a targeted AR campaign on social media to facilitate policy implementation. We believe that these findings are also applicable to other similar AR interventions aimed at changing behaviour and warning about consequences that are usually "out of sight".

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Appendix A: Additional figures and tables

Table A
Socio-demographic characteristics

		Control (%)	AR (%)	AR - Field (%)	Total (%)
Gender	Male	7 (24%)	27 (47%)	36 (49%)	70 (44%)
	Female	22 (76%)	30 (53%)	37 (51%)	89 (56%)
	Total	29	57	73	159
Education	Bachelor degree	9 (31%)	29 (51%)	16 (22%)	54 (34%)
	Master degree	9 (31%)	15 (26%)	14 (19%)	38 (24%)
	Other	11 (38%)	13 (23%)	43 (59%)	67 (42%)
	Total	29	57	73	159
Average age		23.31	23.81	26.01	23.64
Average EES		3.43	3.44	3.67	3.44
Average Use of AR		1.76	1.77	1.69	1.77

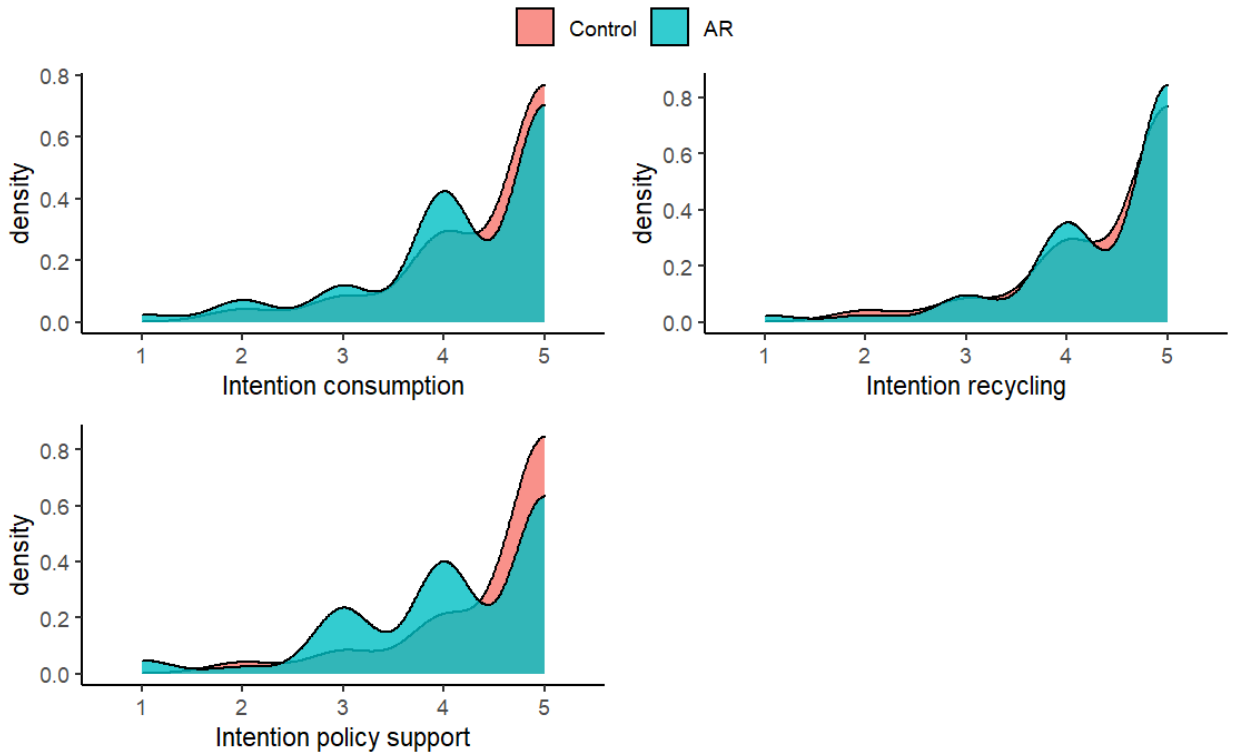


Figure A: Distribution of items composing Preparedness to act.

AR for promoting pro-environmental behavior and attitudes

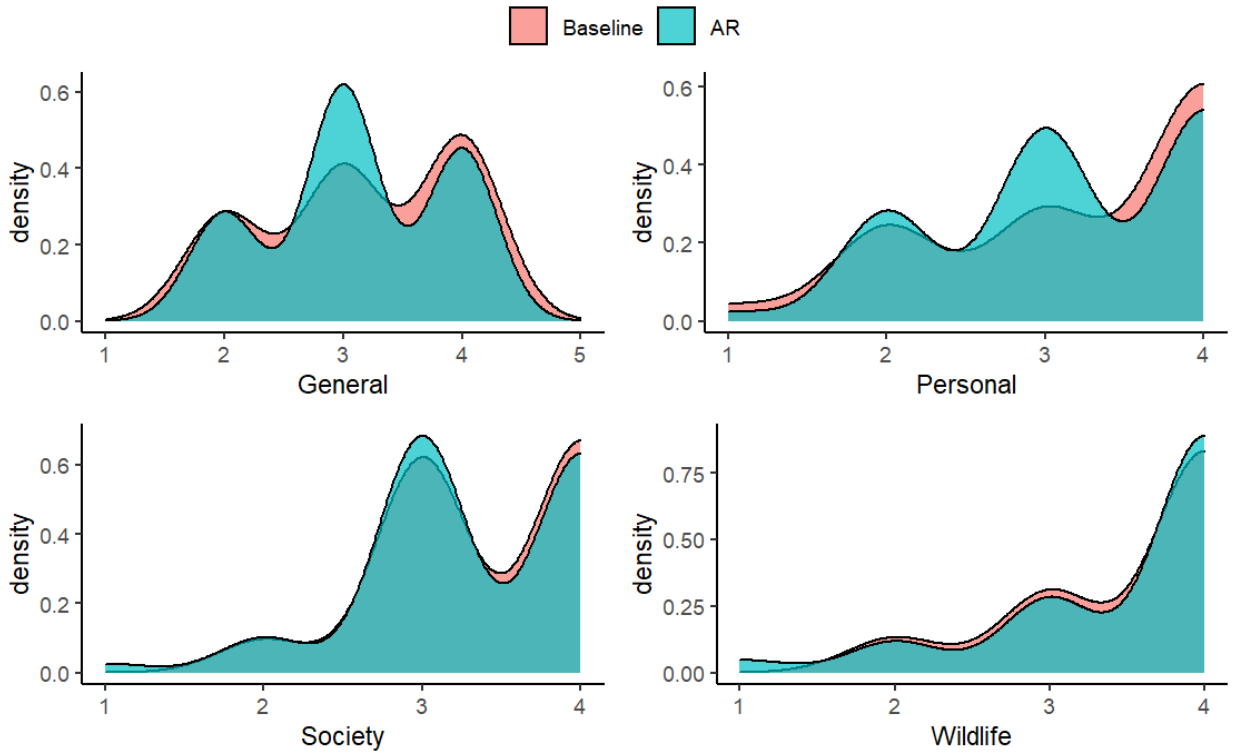


Figure B: Distribution of items composing Concern for plastic pollution.

Appendix B: Experimental material

Table B
Pre-questionnaire

Variable	Questions	Answer options
Environmental Engagement Score (EES)	I consider myself to be an eco-responsible person.	5-points scale (Strongly agree – Strongly disagree)
	I generally feel concerned about environmental issues.	5-points scale (Strongly agree – Strongly disagree)
	Whenever I can, I choose eco-responsible products.	5-points scale (Strongly agree – Strongly disagree)
	Whenever I can, I recycle the waste.	5-points scale (Strongly agree – Strongly disagree)
Past donation (donated before)	Have you ever donated money to an environmental organization?	5-points scale (Never – More than 10 times)
Organization (organization)	Which of these agencies would you be willing to donate money?	4Ocean Colibris 06 Nice Fondation Prince Albert II de Monaco Greenpeace, National Geographics Parley Plastic Pollution Coalition Surfrider The Ocean Cleanup The Sea Cleaners World Wildlife Fund (WWF) Zero Waste France
Frequency smartphone (use_smartphone)	Please indicate how often do you use smartphone.	5-points scale (I never used it – I use it everyday)
Frequency video games (use_video_games)	Please indicate how often do you use videogames.	5-points scale (I never used it – I use it every day)
Frequency AR (use_AR)	Please indicate how often do you use augmented reality.	5-points scale (I never used it – I use it every day)
Frequency social networks (use_social_media)	Please indicate how often do you social networks.	5-points scale (I never used it – I use it every day)
Frequency AR filters (use_AR_filters)	Please indicate how often do you use augmented reality filters on social networks.	5-points scale (I never used it – I use it every day)
Age (age)	Age	Short answer
Gender (gender)	Please indicate how often do you use smartphone.	Male / Female
Study level (study_level)	Last diploma	Without study Primary school / college Secondary school with the bac Bachelor Master Doctorate Other
Study field (study_field)	Field of study	Short answer
Pet (has_pet)	Do you have a pet?	Yes / No
Vacation preferences (perfect_vacation)	For you, perfect vacation is...	In forest / mountain At the sea In the city In the countryside At home Other
Glasses (wears_glasses)	Do you wear glasses	Yes, regularly Yes, sometimes No, never
Vegetarian (vegetarian)	Are you vegetarian	Yes (I don't eat meat or fish) Yes (but I eat fish) No

Figure C: Text about plastic pollution

Chaque année, des millions de tonnes de plastique sont déversées dans les océans. Si aucune action n'est entreprise, l'impact des plastiques sur nos écosystèmes, notre santé et nos économies va être de plus en plus préoccupant. Nous devons prendre toute la dimension du problème en stoppant en amont la production de plastiques et en nettoyant nos océans des déchets plastiques non dégradables. Votre don nous aidera à agir pour une planète débarrassée de la pollution par les plastiques.

English translation: Every year, millions of tons of plastic are dumped into the oceans. If no action is taken, the impact of plastics on our ecosystems, our health and our economies will become increasingly serious. We need to address the full scope of the problem by stopping the production of plastics in the first place and cleaning our oceans of non-degradable plastic waste. Your donation will help us take action for a planet free of plastic pollution.

Table C
Main questionnaire

Variable	Questions	Answer options
Geographic distance (PD geographical local and PD geographical distant)	My local area is likely to be affected by pollution	5-points scale (Strongly agree – Strongly disagree)
	Plastic pollution will mainly affect areas far from here.	5-points scale (Strongly agree – Strongly disagree)
Social distance (PD social decountries and PD social loobelle people)	Plastic pollution will mainly affect developing countries	5-points scale (Strongly agree – Strongly disagree)
	Plastic pollution is likely to have a big impact on people like me	5-points scale (Strongly agree – Strongly disagree)
Temporal distance (PD temporal)	When, if at all, do you think France will start to feel the effects of plastic pollution?	7-points scale (Never – We are already feeling the effects)
	Plastic pollution is a completely natural process and is not caused by human activities.	5-points scale (Strongly agree – Strongly disagree – I think there is no such thing)
Uncertainty/scepticism (PD uncertainty cause)	I'm uncertain that plastic pollution is really happening.	5-points scale (Strongly agree – Strongly disagree)
	The seriousness of plastic pollution is exaggerated.	5-points scale (Strongly agree – Strongly disagree)
Concern about plastic pollution (concern pp)	Most scientists agree that humans are causing plastic pollution	5-points scale (Strongly agree – Strongly disagree)
	How concern are you by plastic pollution?	4-points scale (Very concerned – Not at all concerned)
Preparedness to act (intention)	Considering any potential effects of plastic pollution which there might be on you personally, how concerned are you with plastic pollution?	4-points scale (Very concerned – Not at all concerned)
	Considering any potential effects of plastic pollution which there might be on society in general, how concerned are you with plastic pollution?	4-points scale (Very concerned – Not at all concerned)
Donation	Considering any potential effects of plastic pollution which there might be on marine wildlife and animals, how concerned are you with plastic pollution?	4-points scale (Very concerned – Not at all concerned)
	I am prepared to greatly reduce my plastic consumption to help solve the problem of plastic pollution	5-points scale (Strongly agree – Strongly disagree)
Presence (presence)	I am prepared to greatly improve my recycling habits to help solve the problem of plastic pollution.	5-points scale (Strongly agree – Strongly disagree)
	I am prepared to support stricter environmental policies to help solve the problem of plastic pollution.	5-points scale (Strongly agree – Strongly disagree)
Perceived AR effect (perceived AR effect)	You have a chance to win 300 € in a lottery. If you are the winner, how much would you be willing to give to the pro-environmental organization of your choice (chosen during the pre-questionnaire)?	10 options from 0 € to 300 €
	Only for AR Treatment I felt the presence of animals in the room.	5-points scale (Strongly agree – Strongly disagree)
Had similar experience (had similar experience)	Only for AR Treatment The augmented reality experience brought me closer to the problem of plastic pollution.	5-points scale (Strongly agree – Strongly disagree)
	Only for AR Treatment Have you ever had a similar experience with augmented reality?	5-points scale (Strongly agree – Strongly disagree)

LB11 PRE-QUESTIONNAIRE

Bonjour et bienvenue au LEEN (Laboratoire d'Economie Expérimentale de Nice) !

Vous allez participer à une expérience de prise de décision. La tâche à laquelle vous allez participer consiste à compléter 2 questionnaires et à lire un texte. L'expérience prend une trentaine de minutes.

Dans cette expérience, chaque participant a une chance égale de gagner 300 € lors d'une tombola. Vous avez reçu un code que vous devrez indiquer dans le questionnaire. Veuillez conserver ce code. Nous l'utilisons pour annoncer le gagnant de la tombola. Dans le cas où vous seriez le/la gagnant(e) de la tombola, vous avez la possibilité de faire un don à une organisation pro-environnementale de votre choix.

La tombola sera faite en ligne (conférence Zoom) à une date et un créneau qui vous seront annoncés par email. Elle sera enregistrée pour ceux/celles qui ne pourraient pas y participer. Le don à l'organisation pro-environnementale se fera après la tombola, et une preuve de paiement sera adressée à tous les participants.

Votre participation à cette enquête implique votre compréhension des informations suivantes.

Tâches et temps : L'expérience durera environ 30 minutes.

Confidentialité : la participation à cette étude est anonyme. Les données que nous recueillons seront utilisées dans nos articles de recherche académique (communications à conférences, publications scientifiques) dans le cadre d'un projet multidisciplinaire. Les données que nous recueillons ne seront pas vendues.

Rémunération et participation volontaire : vous serez rémunéré(e) pour votre participation à l'étude. Vous êtes libre de refuser de participer à cette étude ou d'y mettre fin à tout moment au cours de l'étude. Toutefois, seule la pleine participation (questionnaires complétés et participation à l'expérience en laboratoire) pourra être rémunérée.

Vous pourrez compléter ce questionnaire seulement une fois, et vous n'aurez pas la possibilité de stopper le questionnaire et le recommencer dans un deuxième temps.

[Suivant ▶](#) [Sortir et effacer vos réponses](#)

Figure D: Screenshot of pre-questionnaire page.

*** Vous avez une chance de gagner 300 € lors d'une tombola. Dans le cas où vous êtes le/la gagnant(e), quelle somme seriez-vous disposé(e) à donner à l'organisation pro-environnementale de votre choix (choisie lors du pré-questionnaire)?**

Veuillez sélectionner une réponse ci-dessous

- 0 €
- 5 €
- 10 €
- 25 €
- 50 €
- 100 €
- 150 €
- 200 €
- 250 €
- 300 €

Figure E: Screenshot of donation game page.

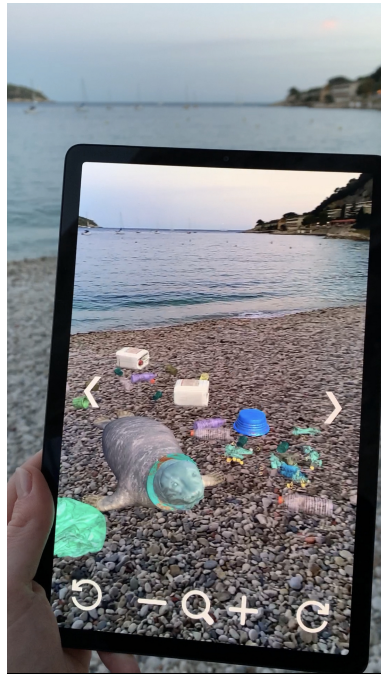


Figure F: Example of AR visualization in Study 2.



Figure G: Lab-in-the-field setup.

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