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Towards a plastic-less planet. Gender and individual responsibility predict the effect of imagery nudges about marine (micro)plastic pollution on R-behavior intentions

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ABSTRACT

Emerging microplastics (MP) pollution is one of the biggest threats for the oceans today. Consumers could reduce MP pollution adopting R-behaviors such as reducing consumption of plastic, refusing products with MP, replacing them for green products, and recycling. Here we tested the efficiency of online nudges (images and short messages) for promoting MP-conscious behavior in Spain ($n = 671$). The perceived level of environmental responsibility and the willingness to adopt R-behaviors were measured. Messages about seafood with MP and plastic-polluted marine environment were more efficient than images of animals killed by plastics. Feeling responsible for MP pollution predicted R-behavior intention. Women would adopt more R-behaviors than men, while men were more sensitive than females to the proposed nudges. Raising the sense of environmental responsibility would be priority in education campaigns. For different cultural sensitivities to animal suffering, evoking environmental health instead of threats to wildlife would be generally recommended.

1. Introduction

1.1. The microplastics crisis and proposed solutions

Plastic waste is increasing and already exceeds the capacity of plastic pollution mitigation (Borrelle et al., 2020). We are paying an enormous toll in environmental and human health (Rodrigues et al., 2019), not to mention the deterioration of marine ecosystems that are sinks for plastic waste (e.g. Grant et al., 2021). Microplastics (MP thereafter) produced from the breakage of larger plastics, or directly as microbeads in personal care products and cleansers, pollute aquatic environments, enter the food chain and release harmful toxic chemicals (Yuan et al., 2022).

Solutions to stop MP pollution are urgently needed. Scientists agree on the need to involve different stakeholders in the fight against MP: the science should find ways to recover and recycle MP from the polluted environment (Chen et al., 2022; Gao and Liu, 2022); the industry should develop alternative products to replace microbeads (Hunt et al., 2021) and plastics (e.g. Rosseto et al., 2019); the governments should implement measures towards MP bans and/or phase out (Mitrano and Wohlleben, 2020; Anagnosti et al., 2021; Deme et al., 2022); and individual consumers should adopt sustainable consumption habits eliminating goods with plastics and MP from their shopping basket (Chang, 2015; Yoon et al., 2021). These changes are a challenge for the whole society that needs to advance towards cleaner ways of production and consumption without clear guidelines regarding this emerging contaminant.

Top-down approaches are being already taken, because an increasing number of countries have banned microbeads from some products like cosmetics (Anagnosti et al., 2021). The European Commission has submitted for public consultation a new regulation that prohibits the addition of all forms of microplastics, allowing transitional periods of up to 12 years for some products like make-up, lip and nail 'leave-on' cosmetics (https://ec.europa.eu/transparency/comitology-register/screen/documents/083921/1/consult?lang=en); after being approved by the EU member states it should be enacted in 2023. Some products that contain primary MP like glitter (Yurtsever, 2019) are not explicitly mentioned in that regulation proposal but its ban is implicit. This approach is double effective because citizens of countries with plastics

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and MP bans will to control MP in their daily life more than those where legislations are less restrictive (Garcia-Vazquez et al., 2023). Thus, conscious behavior of individual consumers is much needed to stop the increase of MP pollution today. In this study, we will try a simple psychosocial intervention based on online exposure to images to identify the type of messages that could be more efficient to stimulate consumer behaviors that prevent MP waste.

1.2. Theoretical background

The R imperatives (Resource Value Retention Options) have been proposed to advance towards sustainability through circular economy (Reike et al., 2018), Recycling being the implementation measure most measured and assessed (Johansen et al., 2022). Plastic recycling has limitations because some countries export the majority of their plastic waste to countries where it is just burnt, not properly recycled (Heller et al., 2020; Law et al., 2020). On the other hand, not all the plastics are equally recyclable (Rahimi and García, 2017). Burrows et al. (2022) found that miscommunication in the labeling of plastic items is one of the causes of limited effectiveness of recycling, often failing to indicate if a plastic is recyclable or not, and if there are regional facilities for recycling. In the particular case of MP, in practice Recycling would be inefficient as a general approach to treat them because they are difficult to recover from general waste due to their small size (Ruggero et al., 2020; Gao and Liu, 2022). Other R behaviors are needed in this case, especially for primary MP such as microbeads. Refuse and Reduce the consumption of products with MP are effective for limiting MP waste if the consumer knows what products contain microbeads or MP. However, as it happens for plastic labels (Burrows et al., 2022), the representation of MP on product labels is insufficiently clear, since being unable to identify microbeads from labels was one of the main obstacles for the reduction of MP reported by students in Mexico and Spain (Garcia-Vazquez et al., 2023).

Even being imperfect for unclear labeling, it is evident that adopting R-behaviors is better than doing nothing to solve the current global MP crisis. The R imperatives that depend on individual consumers (like refusing or reducing plastics consumption, or sorting waste for recycling) can be promoted in different ways. The theoretical framework of pro-environmental or green consumer's behavior generally accepted follows the Theory of Reasoned Action (Ajzen and Fishbein, 1980) and its extension in the Theory of Planned Behavior (Ajzen, 1991), where positive attitudes (assessments of self-performance) towards a pro-environmental behavior, together with perceived control and subjective norms, determine the intention to behave pro-environmentally; such intention plus environment consciousness will finally determine the actual behavior. These theories have been supported from varied studies on green behaviors, like purchasing sustainable clothes (Rausch and Kopplin, 2021) or recycled shoes (Yadav et al., 2022), also for MP control willingness (e.g., Chang, 2015).

Understanding the consequences of the individual behavior is necessary to change it; knowing the impacts of pollution is determinant to align with Recycling, Reusing and Reselling behaviors (Khan et al., 2019). Interventions to reduce waste often recall social norms and education (Byerly et al., 2018); for example, role-playing as children working in Congo cobalt mines increases recycling of mobile phones in Spain –cobalt being essential in electronic devices (Garcia-Vazquez et al., 2021). Simpler interventions are also effective. Nudges like reminders, changing the design of an object, labels or images may suffice to help the consumer to make a quick pro-environmental decision (Wee et al., 2021). Nudging based on short messages can promote different R-behaviors, like recycling food waste (Linder et al., 2018), reducing water (Bhanot, 2021) and energy (Cappa et al., 2020) consumption, and others. We will use short informative messages as nudges in our study. We will accompany the messages with images because there are many examples that show the power of exposure to images in different countries. To mention a few, visual learning based on infographics about plastics recycling and MP formation has been proved an efficient educational tool in USA (Reed and Chen, 2022). Imagery on brochures was sufficient to change environmental attitudes in Australian students (Soutter and Boag, 2019). Wu and Paluck (2021) showed that a simple image of golden coins on the floor was enough to change waste disposal behavior in Chinese workers. Luo et al. (2022) found that the image of a marine animal trapped in plastic debris reduced significantly plastic waste in an experiment in Canada. In this sense, animal images are widely employed to elicit emotions like affect (e.g., Whitley et al., 2021) that helps to increase pro-environmental intentions.

Evoking images related with the sea could be especially efficient. Since the majority of media news focuses on MP content in seafood due to marine MP pollution (Völker et al., 2019), the public is generally concerned about MP impacts on health due to MP ingestion (Deng et al., 2020), and also by MP environmental impacts on the sea (Catarino et al., 2021). Working with ocean imagery (the way people imagine the ocean), Engel et al. (2021) discovered that pro-environmental behavior is positively associated with the psychological impression and environmentalist views of the ocean. Consistently with the effect of ocean imagery, consumer's awareness about the ocean seems to be related with pro-environmental behavior related with the use of plastics in different cultures. In the UK, Nuojua et al. (2022) found that those feeling more connected with the ocean considered plastic packaging more harmful. In the same vein, feeling responsible for the marine environment is associated with recycling and reduced consumption of single-use plastic goods in Spain and Mexico (Garcia-Vazquez et al., 2022). The sense of social responsibility and feeling guilty about ocean pollution mediates between the MP risk perception and the intention to control MP in Korea (Jeong et al., 2021), thus recalling the ocean environment could be a plus for interventions aimed at increasing consumer's MP control.

Regarding the format of interventions, the Internet, including social media, is the main source of information about MP in different countries (e.g. Didegah et al., 2018; Cammalieri et al., 2020). Research has demonstrated that the use of Internet has a positive effect on pro-environmental behavior (Xiao et al., 2022), and also the efficiency of digital interventions (Wolstenholme et al., 2020). Online exposure to messages and images is easy, aligns with nudging methodology (Wee et al., 2021), and may simplify pro-environmental campaigns. For these reasons, we will use Internet as a vehicle for the planned interventions, focusing on Spain where microbeads are not banned yet (Anagnosti et al., 2021) thus individual consumer's behavior is especially important.

1.3. Objectives and departure hypotheses

The objective of this study was to determine if the online observation of images related with MP is sufficient to promote the willingness to adopt R-behaviors for the control of MP.

Expectations, summarized in Fig. 1, were:

i) From the efficiency of nudging online interventions for the promotion of sustainable behaviors (Wee et al., 2021), we expect the online exposure to information about MP impacts will suffice to increase the willingness to behave pro-environmentally.
ii) From the public concern raised by seafood MP pollution and environmental MP impacts (Catarino et al., 2021), and the power of imagery using animals (Luo et al., 2022), images recalling seafood contamination, ocean pollution and plastic threat to animals will increase the willingness to adopt R-behaviors about plastics and MP consumption; for their emotional content images of animals (Whitley et al., 2021) are expected to be more efficient than images of inanimate elements.
iii) For the importance of environmental awareness (Yadav et al., 2022), feeling responsible for marine MP pollution will be positively correlated with pro-environmental intentions regardless the treatment.

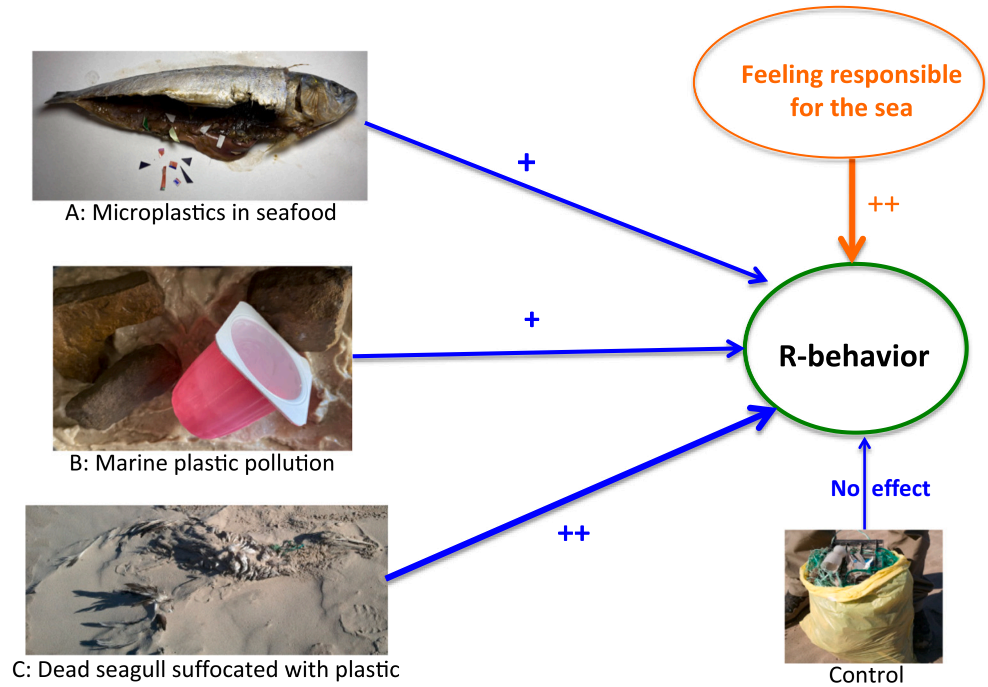

Fig. 1. Expected effects of the experimental interventions and the feeling of responsibility for the ocean on R behavior intentions.

2. Material and methods

2.1. Ethics considerations

The study was approved by the Committee of Research Ethics of Asturias Principality (Spain) and assigned it the reference CEImPA:2021.116. Researchers informed the participants about the objective, the use of their answers for research purposes only and their right to withdraw from the study in any moment. Participants signed an informed consent online. We followed the principles of the Declaration of Helsinki adhering to the European code of conduct for research integrity (All European Academies, 2017).

2.2. Work overview

This work was organized in three different studies. In Study 1, R-behaviors were compared between a sample of general population (non-students) and the control group of students, both with the same introductory image of a garbage bag, to check if the condition of being a student in the experimental groups did not bias the study; with no evidences of that, the results could be generalized to the Spanish population. In Study 2, the results of R-behavior and pro-environmental engagement intentions were compared across four experimental groups of students: three treatments based on different images related with ocean pollution by plastics, and a control. In Study 3 multiple regression analysis was done on the whole sample - including students and non-students, to determine the relative weight of socio-demographic factors, the feeling of responsibility for the ocean, and the treatments, on R-behavior intentions.

2.3. Experimental setting and treatments

The experiment was entirely developed online. Four treatments were designed, each consisting of an image (Fig. 1) and a short informative sentence about an issue related with MP. Treatment A evoked issues for seafood consumers. The image exhibited a fish open with MP inside, with an introductory sentence “MP may be ingested inadvertently when eating marine products like mussels or fish.” and the figure caption “Microplastics inside a fish”. In Treatment B, devoted to marine pollution, the image was a plastic object on seafloor, the introductory sentence “Microplastics represent a threat for the planet, being found even on the oceans bottom” and the figure caption “Plastic waste on the seafloor”. Treatment C intended to elicit compassion for wild animals exposed to MP waste. It combined a photo of the remains of a seagull entangled with a plastic rope with the caption “Carcass of a seagull strangled by plastics” and the introduction “Microplastics pose a risk to emblematic species such as seabirds”. Finally, in the Control treatment the image was a garbage bag full of plastic waste, with a neutral sentence not expected to elicit any attitude towards MP “This questionnaire is part of a research about microplastics, that are small pieces or fragments of plastic”.

In the online survey, participants enter a link that takes them directly to a digital version of the questionnaire for self-administration. Subjects will find first a brief introduction stating that the information is gathered for research purposes only, and a form for the informed consent. The consent is compulsory to continue; if the case is not marked the survey ends. In the next page the introductory image and short message corresponding to each treatment are displayed, followed by a questionnaire. The first four questions (A.1-A.4) are about socio-demographic issues: gender (0 man, 1 woman, 2 non-binary), age (groups 1 to 6, by decades), educational level (1 to 6 from primary education to doctorate) and formation background according to the main formation discipline (qualitative variable: Natural sciences, Health sciences, Social sciences and Humanities, Engineering). Then a question about how often the respondent checks microbeads from personal care products and cleansers is posed (B.1; scale 1–5 from never to always), being a proxy to the actual awareness of MP. In the next section (scale 1–7), there is a question to evaluate the participant's ocean pollution awareness, formulated as “I feel personally responsible about the marine pollution caused by MP”, four questions to measure the willingness to adopt R-behaviors (Reduce plastics consumption, Refuse products with MP, Replace them for green products, sort litter for Recycling), and one question about the willingness to engage in environmental actions. The estimated time to complete this short questionnaire is about 5–10 min.

2.4. Experimental groups and procedure

The untreated group of non-students in Study 1 was described in Garcia-Vazquez et al. (2023). It was recruited using snowball methodology (Valerio et al., 2016), starting with university students that were asked to pass an online link to their acquaintances as explained therein (Garcia-Vazquez et al., 2023).

The four experimental groups of undergraduate students were recruited directly in the classes where the teachers provided a link to the online survey, randomly assigning each subject to an experimental group. Teachers explained that it was a research project and the participation was for outside the class, voluntary and free, not being paid nor compensated with benefits in the course in any way. Participants were clearly informed about the project, authors, and policy for anonymous data treatment, as well as about their right to withdraw from the study at any time.

2.5. Statistics

2.5.1. Estimates of minimum sample sizes and post-hoc statistical power

Minimum sample size for adequate study power was determined for similar group sizes ($k = n_1 / n_2 = 1$), 90 % minimum power, $\alpha = 0.05$, $\beta = 0.2$, anticipated means μ_1 and μ_2 and their difference Δ. The anticipated means of the control for the willingness of reduction of plastic consumption and recycling in the Spanish population were taken from Garcia-Vazquez et al. (2022), and for the willingness to refuse consumption of products with MP and replace them for green products from Spanish data in Garcia-Vazquez et al. (2023). For conservative approach we considered a 10 % increase of the mean as a result of the treatment. The formula employed was:

$$n_1 = \left(\sigma^2{}_1 + \sigma^2{}_2/K\right)\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2 \Big/ \Delta^2$$

Post-hoc statistical power (Φ) was calculated only for cases with significant results as recommended in Levine and Ensom (2001), based on Z-value for $\alpha = 0.05$ (1.96), mean difference Δ, group variances and sample sizes (n), according to the formula:

$$\Phi = -Z_{1-a/2} + \Delta/\sqrt{\left(\sigma^2{}_1/n_1 + \sigma^2{}_2/n_2\right)}$$

2.5.2. Statistical tests

Contingency analysis based on chi-square χ^2 was employed to check for homogeneity of experimental samples regarding qualitative or discontinuous variables like gender, age group or the proportion of different discipline backgrounds.

Differences between group means for socio-demographic variables like age and educational level, and for behavioral variables like checking microbeads from personal care products, were tested using ANOVA. Homoscedasticity was checked from Breusch-Pagan test and normality from Shapiro-Wilk test. Non-parametric Kruskal-Wallis test was used when normality requirement was not met. When homoscedasticity was not met Welch's F test was employed. In the experiment, two-way ANOVA was employed to determine differences in means between groups for each factor i.e. behavioral intentions (five levels) and treatments (four levels) and the interaction between factors. Repeated-measures ANOVA was employed to compare between treatments considering simultaneously the five behavioral intentions. Post-hoc pairwise Tukey tests were conducted after significant ANOVA; t-test was employed to compare means between two samples, or Mann-Whitney when normality was not met.

Effect-sizes for the comparisons between two means were measured from Cohen's d and the effect size correlation r_{Yl}. The statistics ω^2 was used as an estimator of effect size in ANOVA analysis. Cramer's V was employed as a proxy for the effect size in contingency analysis, as in Razzini et al. (2020).

Multiple regression analysis was employed to determine which independent variables, i.e. gender, age, treatment and attributed personal responsibility, predicted the variation of the dependent variables, i.e. the mean behavioral intention. To transform the treatment into a quantitative variable we order the treatments by effect, giving 0 to the control and up to 3 to the rest, ordered by the relative effect. Statistics was performed with free software PAST version 4.12 (Hammer et al., 2001).

3. Results

3.1. Overview of experimental groups

With the setting and values explained in 2.4.2, the minimum sample size required for 80 % statistical power was 47, 58, 65, and 45 for the willingness to reduce plastic consumption, recycle, refuse products with MP and replace them with green products, respectively.

In total 324 people participated in this study: 73, 86, 82 and 83 for treatments A, B, C and the control respectively. All the group sizes were larger than the minimum sample sizes estimated, thus the study can be considered robust.

The four experimental groups were quite homogeneous; a description is presented in Table 1. The majority of participants were females between 18 and 30 years old, with mean educational level higher than secondary education, and had a background in social sciences. No significant differences between the four experimental groups were found for any of the considered socio-demographic factors: gender (contingency $\chi^2 = 6.36$, 3 d.f., $p = 0.095 > 0.05$ n.s., moderate Cramer's V = 0.14), age (Kruskal-Wallis tie-corrected Hc = 2.673, $p = 0.447$ n.s.), mean educational level (Kruskal-Wallis Hc = 2.457, $p = 0.483$ n.s.), and the profiles of formation disciplines (contingency $\chi^2 = 10.2$, 9 d.f., $p = 0.33$ n.s., small Cramer's V = 0.103). Thus we can reasonably assume that the groups are similar enough to control biases from these factors in the experiment.

3.2. Study 1

As described in Garcia-Vazquez et al. (2023), the non-students sample size was $n = 347$, being 149 women (42.9 %), 196 men (56.5 %) and two non-binaries. The mean age group was 2.62 ($SD = 1.4$) and

Table 1
Description of the experimental groups. The following socio-demographic characteristics are given: self-informed gender as proportion of females; average age group, as 1 = 18–30, 2 = 31–40, 3 = 41–50, 4 = 51–60, 5 ≥ 60; mean formation level being 2 secondary, 3 graduate, 4 post-graduate and 5 doctorate; and formation disciplines as percentage of participants of each discipline. The mean frequency of checking microbeads from cleansers and personal care products is presented (from 1 = never to 5 = always), as well as the feeling of personal responsibility for MP pollution (from 1 = totally disagree to 7 = totally agree). Sample size = n. Standard deviation in parentheses.

	A	B	C	Control
n	73	86	82	83
% females	65.7 %	74.4 %	58.02 %	69.9 %
Mean age group	1.18 (0.75)	1.1 (0.47)	1.16 (0.64)	1.25 (0.44)
Mean educational level	2.41 (0.86)	2.42 (0.64)	2.54 (0.76)	2.46 (0.72)
% Natural sciences	11.1 %	17.4 %	19.7 %	18.7 %
% Health sciences	13.9 %	16.3 %	21 %	11.3 %
% Social sciences & Humanities	72.2 %	61.6 %	53.1 %	63.7 %
% Engineering	2.8 %	4.7 %	6.2 %	6.3 %
Checking microbeads from products	1.37 (0.74)	1.42 (0.87)	1.45 (0.89)	1.56 (0.92)
Personal responsibility attribution	4.33 (1.78)	4.24 (1.67)	4.48 (1.79)	3.92 (1.97)

The raw data of the four experimental groups are provided in the Supplementary Table 1.

the average educational level 3.3 ($SD = 0.8$), meaning that the majority were graduate or above. Compared to the groups of students (Table 1), this sample of Spanish non-students had a higher proportion of men, education level, and, logically, a higher mean age (statistics not shown). The mean feeling of personal responsibility for MP pollution was 3.93 ($SD = 2.07$); it was 3.92 ($SD = 1.97$) for the control group of students, indeed not significantly different and with almost negligible effect size ($d = 0.005$, $r = 0.002$). The mean frequency of microbead checking was 1.65 ($SD = 1.08$), not significantly different of that of control students presented in Table 1 (mean = 1.56, $SD = 0.92$; $t = 0.686$ with $p = 0.49$, very small effect size with $d = 0.089$, $r = 0.045$).

The mean values for the five behavioral intentions in the group of non-students were very similar to those found for the control in the experiment, almost identical (Fig. 2). Accordingly, the individual mean of these behaviors was not significantly different between the two groups of subjects (5.2 with variance 3.1 in the group of non-students versus 5.22, variance 2.84 in the control group of students; $t = 0.126$ with $p = 0.89$). The effect size was very small with $d = 0.026$ and $r = 0.013$.

In these groups the willingness to adopt sustainable behaviors was not the same for the five proposed actions (ANOVA $F = 16.12$ with $p < 0.001$, $\omega^2 = 0.027$). Recycling was the preferred R-behavior, and pro-environmental engagement the least desired action, only not significantly different of Replacing (buying green products) that was the second least preferred (Fig. 2, Supplementary Table 2).

The similarity of student and non-student samples would suggest that the results obtained in this study are at least moderately representative of the general population and not limited to Spanish students.

3.3. Study 2

The frequency of the four experimental groups for the behavior of checking microbeads from cleansers and personal care products was very similar (Table 1), and not significantly different among groups (Kruskal-Wallis Hc = 2.899, $p = 0.408$ n.s.). Thus the results of the experiment would not be biased by differences between groups regarding the awareness about MP.

Pro-environmental behavior intention was different among the four experimental groups (Fig. 3). For the five behaviors considered, those exposed to a picture of a MP-polluted fish (group A) declared the highest willingness to reduce plastic and MP consumption (Reduce), buy eco-friendly products (Replace), sort litter (Recycle) and collaborate in pro-environmental actions. The next group was the one exposed to a picture of plastics on the marine bottom (group B). Group C, exposed to the photo of a dead seagull suffocated with plastics, was the next in the reduction of plastic consumption and recycling, but the last in the other three proposed behaviors (Fig. 3). The mean of the five intended behaviors followed the order A > B > C > Control (5.5 ± 0.79, 5.39 ± 0.82, 5.129 ± 0.83, and 5.125 ± 0.91, respectively).

From two-way ANOVA results, the willingness to adopt behaviors aimed at MP control was significantly different among both the treatments ($F = 5.01$, $p = 0.002$) and the types of behavior ($F = 24.87$, $p < 0.001$) in this experiment (Supplementary Table 3).

Regarding the type of behavior, as in the Study 1 *Recycle* was clearly the preferred option, significantly above the rest (Supplementary Table 4 for post-hoc pairwise test), followed by *Reduce* plastic and *Refuse* MP consumption (both significantly higher than pro-environmental actions). Then *Replace* was not significantly different of *Reduce* and *Refuse*, neither of pro-environmental engagement that was the least preferred behavior (Fig. 3, Supplementary Table 4).

The treatment was also significant in two-way ANOVA. The objective being to test the effect of treatments on all the behaviors, we conducted an ANOVA test of multiple measures (five measures of intended behavior to control MP pollution). The result was highly significant with $F = 17.2$ and $p < 0.001$. Post-hoc tests demonstrated that both A and B treatments increased pro-environmental behavior intention in comparison with the control (large effect sizes of $d = 1.346$ and $r = 0.558$, and $d = 0.943$ and $r = 0.426$ respectively; respective statistical power of Φ = 84.3 % and 57 %), while treatment C did not differ from the control (Supplementary Table 5) with small effect size of $d = 0.014$ and $r = 0.07$.

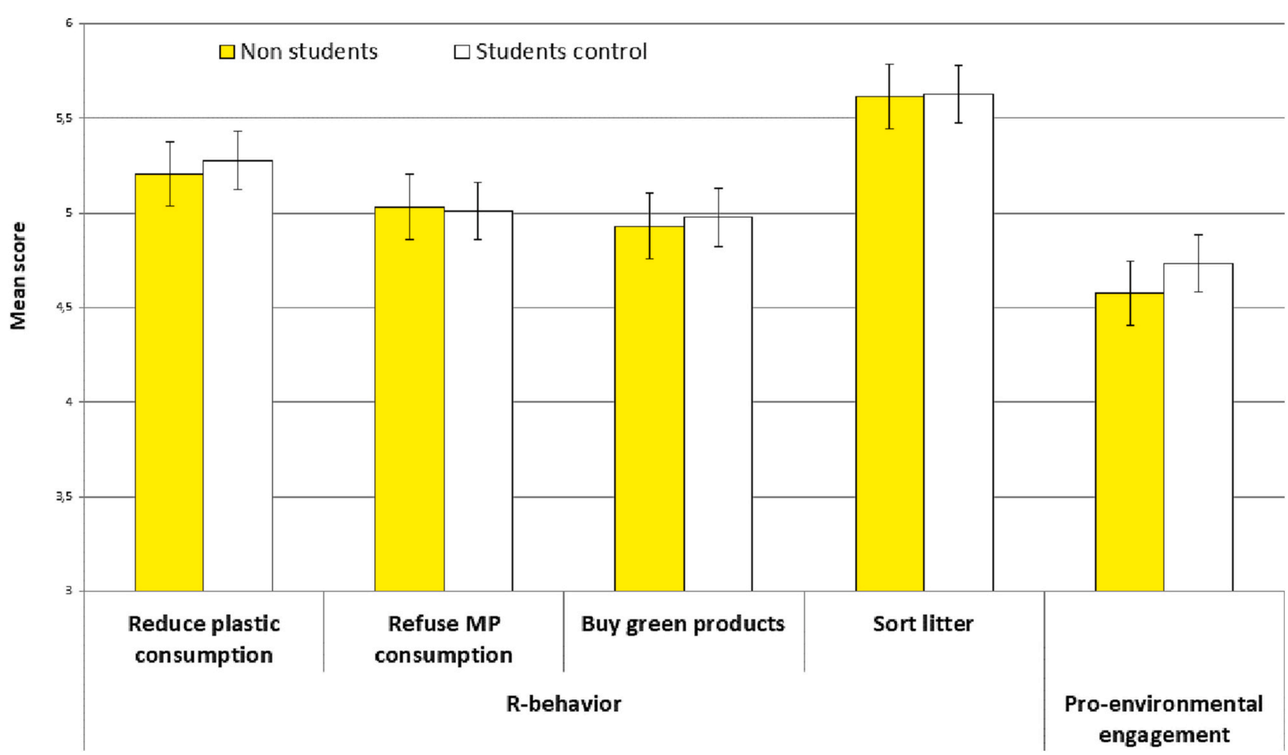

Fig. 2. Pro-environmental behavior intentions in the group of non-students ($n = 347$) compared with the control group of students ($n = 83$). Results are presented as mean scores of each behavioral intention, for each group (standard errors as capped bars).

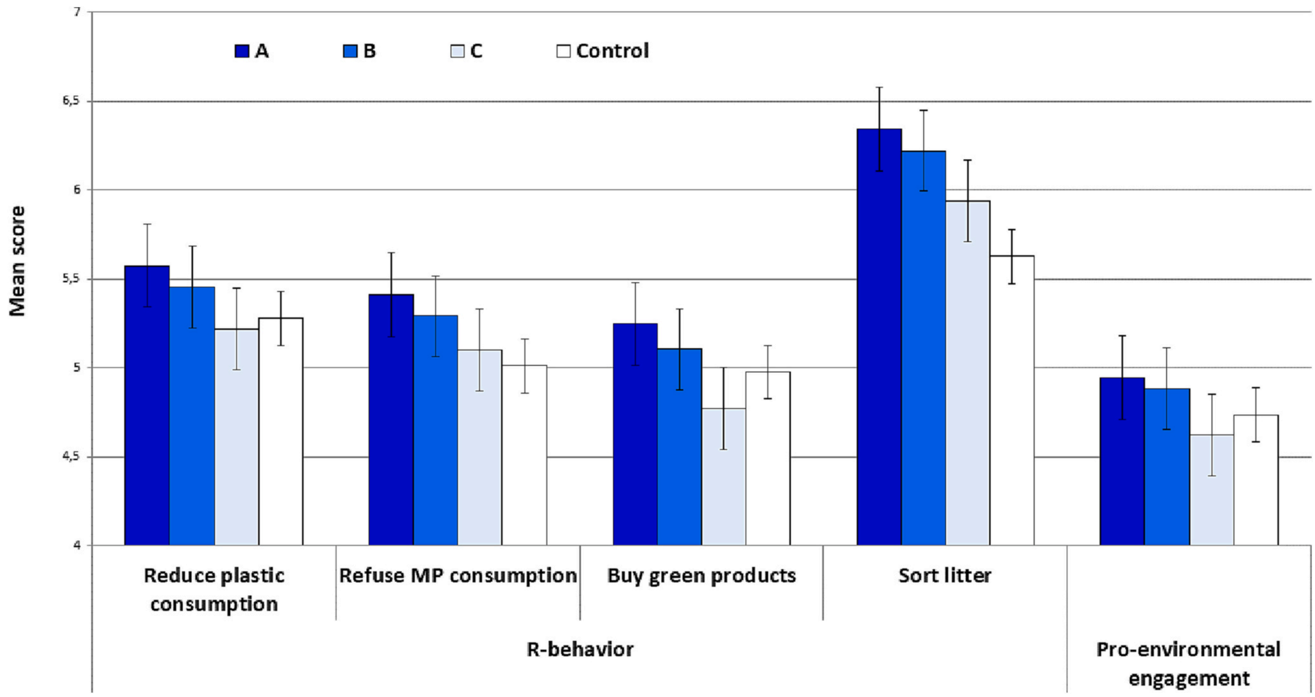

Fig. 3. Results of the experiment presented as means of the pro-environmental behavior intentions considered. Experimental groups were exposed to images: A, contaminated seafood; B, plastics in sea bottom; C, dead seagull suffocated with plastic ropes; Control, a bag with litter. Standard errors as capped bars.

A and B treatments also differed significantly from C (see Supplementary Table 5). Thus the relative efficacy of the treatments observed in Fig. 3 was confirmed from this statistical analysis.

3.4. Study 3

In this study we run multiple regression with the mean of R-behaviors as dependent and interventions (treatments), the awareness of MP proxy (the frequency of checking microbeads from product labels) and socio-demographic variables, considering together all the subjects of these studies. Controlling the rest of variables, treatment efficiency indeed predicted R-behavior intention ($t = 2.784$, $p = 0.006$, $r^2 = 0.01$; Supplementary Table 6), consistently with ANOVA results in Study 2 (see Supplementary Table 3). The self-attributed responsibility for MP pollution highly significantly predicted the willingness of R-behavior ($t = 12.78$, $p < 0.001$, $r^2 = 0.201$). The actual awareness of MP, here

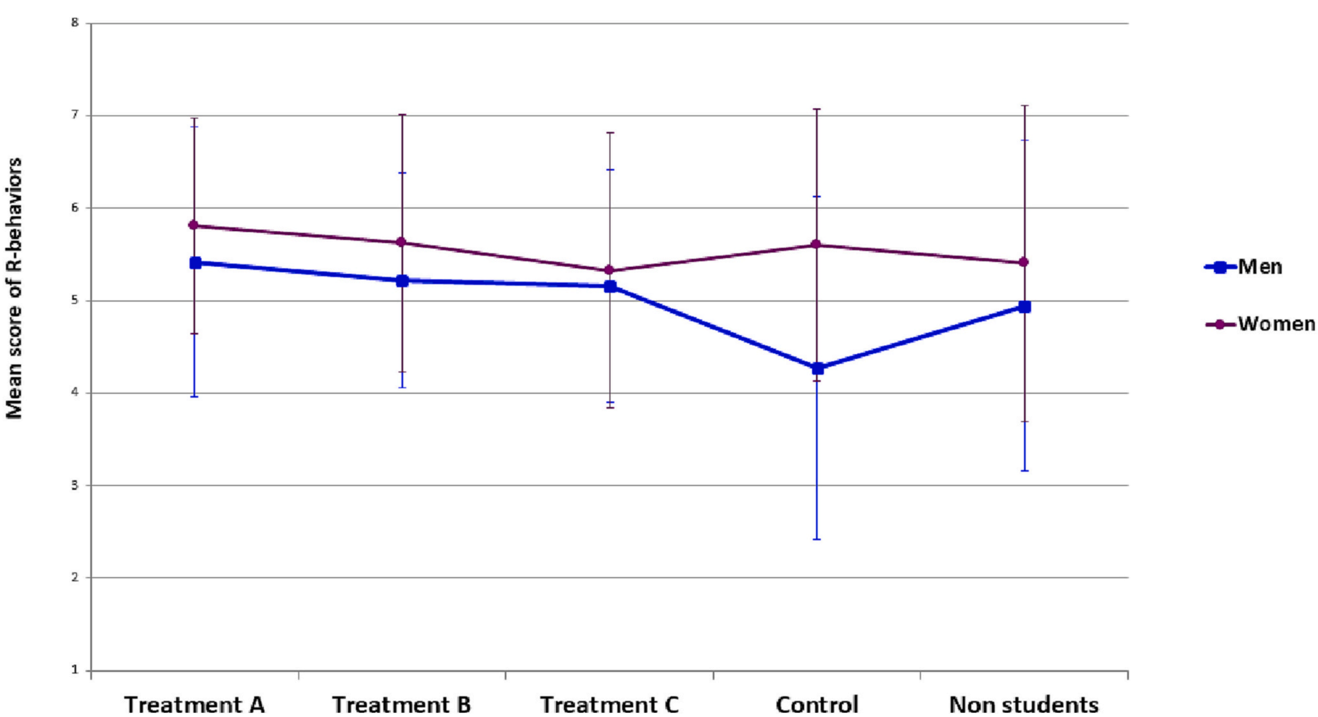

Fig. 4. Means of the pro-environmental behavior intentions found in the experimental groups (Treatments A, B, C and Control) and in the group of non-students, by gender. Standard errors as capped bars.

represented from the behavior of checking microbeads from product labels, did not predict significantly R-behavior intentions ($t = 0.11$, $p = 0.912$ n.s.). Of the socio-demographic variables considered only the gender was significant: being a woman (because the sign was positive, and coding was woman = 1, man = 0) predicted significantly the willingness of adopting R-behaviors in the samples here studied ($t = 3.112$, $p = 0.002$, $r^2 = 0.022$; Supplementary Table 6).

The effect of the gender in the whole samples was unexpected, because in the sample of non-students alone, the effect of the gender was not significant ($F_{3,\ 565} = 1.67$, $p = 0.17$, > 0.05, n.s.; Garcia-Vazquez et al., 2023). To understand better this effect, we conducted one-way ANOVA analysis to check the effect of the experimental treatments in men and women separately. Results showed that women declared higher R-behavior intention means than men, in all the experimental groups and in the non-students (Fig. 4), which explains the significance obtained for the effect of gender in multiple regression analysis in this study. However, the differences between the five groups were not significant in women (Welch's $F_{140} = 1.242$, $p = 0.296$, $\omega^2 = 0.004$). Only Treatment A had a higher R-behavior than the Control and the non-students, but the values were not much different. Only the largest pairwise difference (between Treatment A and the lowest Treatment C) was marginally significant (<0.10 but >0.05): $t = 1.91$, $p = 0.059$, Cohen's $d = 0.41$.

In the case of men, the results were clearly different from those of women. First, in male students all the treatments had higher means than the control (Fig. 4), and the difference between student groups was significant ($F_{3,100} = 2.99$, $p = 0.03$, $\omega^2 = 0.054$). Even the least efficient treatment C had a significantly higher mean of R-behavior intentions than the control ($t = 2.17$, $p = 0.03$, moderate $d = 0.203$); indeed, the mean of Treatment A was also significantly higher than that of the control ($t = 2.38$, $p = 0.02$, Cohen's $d = 0.702$), as it was that of Treatment B ($t = 2.05$, $p = 0.046$, Cohen's $d = 0.619$). The apparent difference between the experimental control and the group of non-students was not significant: respective means of 4.27 with $SD = 1.85$ and 4.94 with $SD = 1.78$; $t = 1.7$, $p = 0.09$, $\omega^2 = 0.26$. Summarizing these results, the treatments had a significant effect in student men but not in women in this study.

4. Discussion

4.1. Accomplishment of departure expectations and study novelties

Here, we demonstrate the efficiency of the online exposure to images and short informative messages as nudges for increasing the willingness to control MP, confirming the departure hypotheses under some conditions that are summarized in Fig. 5. Briefly, the nudges employed in this online experiment promoted a significant increase of the willingness to adopt R-behaviors (Hypothesis i) in men. Images of dead marine animals entangled with plastics increased R-behavior intentions, but not more than images of seafood polluted with MP or plastic garbage on the sea bottom (Hypothesis ii). In line with Jeong et al. (2021), feeling responsible for marine MP pollution was a highly significant predictor of the willingness to adopt R-behavior confirming Hypothesis iii. Finally, being a woman (versus a man) predicted higher R-behavior intention, but the exposure to the nudges employed in this experiment was not significant in student women.

These results are novel in various aspects. First, the efficiency of nudging to increase pro-environmental behavior is already known (Wee et al., 2021, and references therein), but to our knowledge this is the first experiment that demonstrates R-behaviors can be promoted from online nudging based on MP. Second, in our experiment we found a significant effect of the gender, women willing to adopt R-behaviors for the control

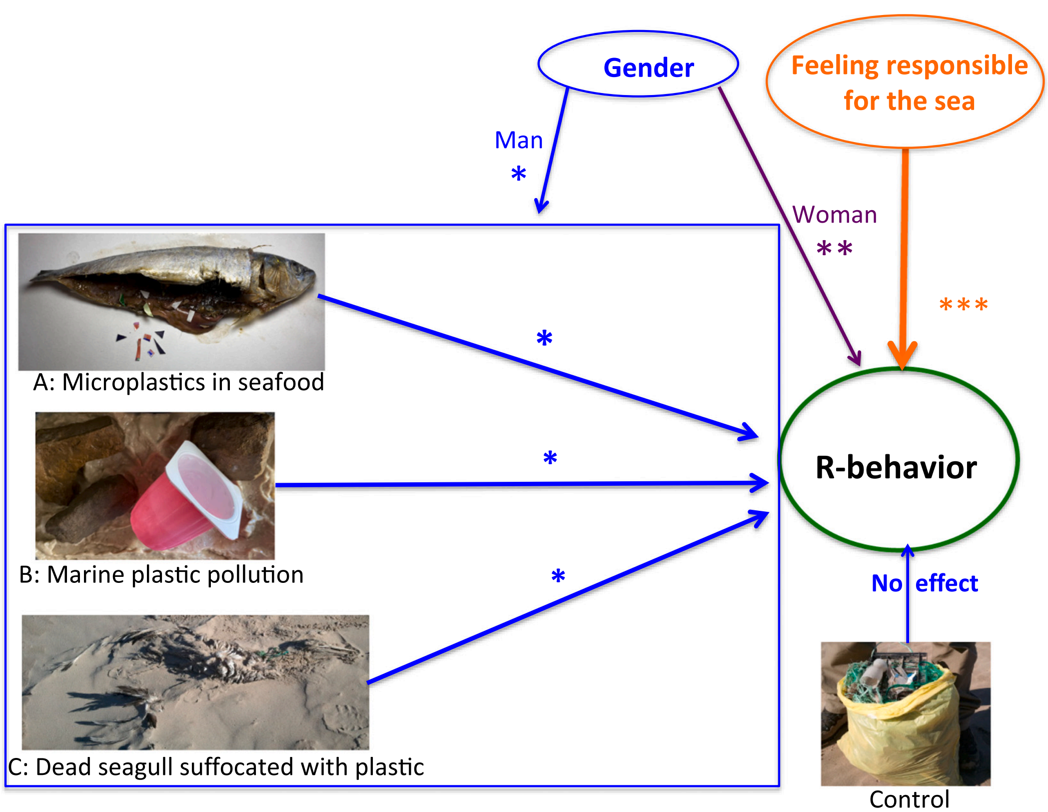

Fig. 5. Visual summary of the results of this study. The importance of feeling responsible for the sea and the effect of gender – interventions being significantly effective only in men- are represented by arrows. R-behavior is the mean willingness to adopt the five pro-environmental behaviors considered: Recycle, Reduce, Refuse, Replace products with plastic or microplastics, and engage in pro-environmental activities. Significant increase of R-behavior intention is marked as * for $p < 0.05$ or *** for $p < 0.001$.

of MP more than men but not responding to the exposure to the nudges as men did. This indicates a complex effect of the gender in these behaviors related with MP control, as it happens with other pro-environmental behaviors with results sometimes contradictory or inconclusive (Xiao and McCright, 2015). A higher pro-environmental attitude in women has been found in other studies. For example, the positive effect of the use of Internet on pro-environmental behavior was more pronounced in Chinese women than in men (Xiao et al., 2022), and the same happened for the willingness to reduce MP emissions (Deng et al., 2020). In Spain, the intention to reduce single-use plastics consumption is higher in women than in men (Garcia-Vazquez et al., 2022); however, no significant effect of the gender was found for the willingness to reduce MP, in the same sample of general population employed here in Study 1 (Garcia-Vazquez et al., 2023). When the general knowledge of pollution is taken into account, no significant effect of the gender on pro-environmental behavior to control plastics can be found in Portugal (Soares et al., 2021). Different specific factors may affect pro-environmental behavior in each gender. For example, Vicente-Molina et al. (2018) found that university students do not fit the gender stereotype of women purchasing green and recycling more than men, which was interpreted as a decreasing importance of gender roles in environmental tasks due to gender equality laws and social transformation in the Basque Country. For these authors, men are more sensitive than women to programs attempting to influence their behavior towards the environment because they have more elastic pro-environmental values (Vicente-Molina et al., 2018). Our results would be consistent with their findings.

A saturation effect could be also considered here to explain the lack of effect of the nudges in women. In the present case, women seem to be already behaving pro-environmentally more than males, also in the control and in non-student samples, thus the exposure to more information about the impacts of MP would not have much effect on them. In men, with more room for improvement of pro-environmental behavior, the exposure to new information about MP impacts would induce the willingness to change their behaviors. A similar reasoning was employed by Garcia-Vazquez et al. (2023) to explain the lack of effect of the knowledge about MP, confirmed here. This effect was found in other studies where highly aware subjects do not increase significantly their pro-environmental behavior when they are exposed to new environmental information and campaigns (Kim et al., 2018; Cammalieri et al., 2020).

Another novelty of our results was the unexpected lack of effect of a dead seagull. In their experiment in Canada, Luo et al. (2022) found a higher impact of signage with marine animals entangled with plastics than of any other type of signage. However, in our results we did not find that effect when using an image of a suffocated seagull. On the contrary, that image did not increase the intention of pro-environmental behavior compared to the control. Cultural differences could explain this apparent contradiction. Spain is one of the European countries with the lowest concern about animal suffering, which is reflected on bullfighting popularity that, although declining in the last decades, is still supported from different sectors of the society (Andrade, 2022). Spaniards also exhibit a low willingness to adopt restrictive regulations on animal welfare, compared with other countries (Pejman et al., 2019). Thus, the relatively low effect of messages based on animal damage seems to be coherent with a culture where animal welfare is not a priority. An alternative or additional explanation could be the clear negativity of the image of a dead gull. Chen (2016) found that fear through negativity has limiting impact on behavioral changes, and Soutter and Boag (2019) found that positive images elicit pro-environmental behavior changes better than negative images. This, together with cultural aspects, could explain this particular and unexpected result.

Here we have demonstrated the power of images to amplify a reaction of willingness to adopt R-behaviors. However, it has to be noted that the risk evoked by those images may not reflect the real degree of harm to birds or risk for consumers the MP can pose. The distribution and biological effects of MP in marine species are still debatable issues because risk assessments have methodological limitations (Zhang et al., 2019). Regarding the impact of the ingestion of plastics in seabirds, experts ranked it much lower than the risk of fisheries bycatch and oiling, or wind turbines (Lieske et al., 2019). For example, Procellariforms (petrels, shearwaters), which have more MP in their stomach than other species (Berr et al., 2020; Kühn and van Franeker, 2020), may ingest MP as they do with grits to help the crushing of preys for digestion; those starved may contain the same amount of MP as those died by accidents (collision, drowning) in healthy conditions, thus MP are not a cause of starvation (Van Franeker and Meijboom, 2002). More studies are needed to fully understand the real types of risk encompassed by birds' MP ingestion, as it happens for many other species and issues (GESAMP, 2016; GESAMP, 2019; SAPEA, 2019). Likewise, MPs in the intestinal tract, like those shown in the image of the fish in this study, are commonly excreted, and the risks of accumulation in tissues and trophic transfer are relatively limited (McIlwraith et al., 2021). Although the efficiency of these images to increase the willingness to control MP seems to be clear, the real risks behind the images employed in this study may be not perceived. Expanding a little bit the messages accompanying the images to reflect better the scientific knowledge (or uncertainty) about the risks could improve the quality of the information and avoid misinterpretation of the message.

Finally, significant differences between R-behaviors were found in this study. Recycling was the preferred R-behavior in all the experimental groups. This may be expected in a country like Spain where the citizens adhere frequently to this behavior (Escario et al., 2020; Garcia-Vazquez et al., 2022). In this sense, plastics recycling is improving rapidly in efficiency thanks to innovative advances in next-generation plastics, like dynamic covalent diketoenamine bonds (Christensen et al., 2019) that will allow closed-loop recycling of plastics; new, improved enzymes to degrade some plastics like polyester (Tournier et al., 2020); or the use of highly effective combinations of chemical processes and biological conversion by engineered bacteria (Sullivan et al., 2022), for example. If advanced recycling technologies became an easy solution to the problem, probably the option of Recycling would be even more preferred than Reducing or Refusing plastic consumption, enlarging the difference between R-behaviors. Perhaps the sense of social responsibility could change, decreasing in some extent the feeling of guilty about ocean pollution; however, small plastic fragments would be still difficult to remove from the ocean and the economic costs of mitigating improper plastic disposal would continue to exist.

4.2. Practical implications

Some practical recommendations could be derived from this study. First, from the efficiency of nudges using images found in our results we could recommend an improvement in labeling of products with MP using images or pictograms to help consumers to make informed choices. Burrows et al. (2022) recommend adding an understandable sustainability scale on plastic labeling, for the consumer to be informed about environmental and human health issues related to plastic use. Today, the European Chemistry Agency (ECHA), that is the European Union chemicals regulator, is in the process of restricting the use of intentionally added microplastic particles to consumer or professional use products of any kind, after European Commission's request (https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18244cd73, accessed March 2023). The new European legislation proposal to ban the addition of all forms of microplastics (Draft Implementing Act D083921/01 at https://ec.europa.eu/transparency/comitology-register/screen/documents/083921/1/consult?lang=en) will no doubt accelerate the process. Until the time of restrictions comes, and in the products with transitional periods, signs about the potential risks of the main chemical of microbeads or MP particles should be added to the label of products containing them. Examples about how to represent those risks visually (as nudges) are the pictograms employed by the ECHA (https://echa.europa.eu/regulations/clp/clp-pictograms, accessed March 2023). From our results, consumers may be especially sensitive to those signs that recall harms for human health and/or for the aquatic environment.

The relative efficiency of pro-environmental messages depending on the culture is another of the main messages of our study. To reduce the consumption of products with MP, an emphasis should be given in Spain to the MP pollution of food rather than messages about environmental risks or animal harm, that being significant in men, would have less effect. Moreover, the image and message about seafood contamination, although only marginally significant, had the highest effect in women too. Similar explorations of most efficient messages and images to cut down MP consumption could be done in other countries to consider the characteristics of local cultures in interventions for environmental awareness.

Public campaigns of information could also take into account the effect of the personal responsibility found in this and other studies (e.g. Jeong et al., 2021; Garcia-Vazquez et al., 2022). Recalling the individual responsibility and the power of consumer's choices to stop current environmental deterioration could be added to informative posters, infographics, brochures and messages, as well as to the public speech of aware politicians and environmental agents if a change from the bottom –the consumer- is sought.

5. Conclusions

This study demonstrates the efficiency of nudges consisting of images and short messages for the increase of the willingness to control MP. These nudges had a significant effect only on men, perhaps because women had already a higher willingness to act pro-environmentally than men.

Although in other countries images of animals impacted from plastics pollution are highly effective in the promotion of pro-environmental behavior, in this study such an effect was not found. This could be interpreted as a possible consequence of the Spanish culture, where animal welfare is a relatively low priority.

According to a strong alignment of Spaniards with recycling behavior, Recycling was the preferred R-behavior chosen by all the participants in this study. Future interventions to increase consumers' control of MP should be tailored taking into account cultural aspects.

CRediT authorship contribution statement

Eva Garcia-Vazquez: Conceptualization, Methodology, Investigation, Data curation, Software, Writing - Original draft preparation. Cristina Garcia-Ael: Supervision, Conceptualization, Investigation, Writing- Original draft preparation. Alba Ardura: Investigation, Writing-Reviewing and Editing. Noemi Rodriguez: Investigation, Writing-Reviewing and Editing. Eduardo Dopico: Investigation, Writing-Reviewing and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2023.115157.

References

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-t.
Ajzen, I., Fishbein, M., 1980. Understanding Attitudes and Predicting Social Behavior. Prentice-Hall.
All European Academies, 2017. The European Code of Conduct for Research Integrity. Berlin-Brandenburg Academy of Sciences and Humanities, Berlin.
Anagnosti, L., Varvaresou, A., Pavlou, P., Protopapa, E., Carayanni, V., 2021. Worldwide actions against plastic pollution from microbeads and microplastics in cosmetics focusing on European policies. Has the issue been handled effectively? Mar. Pollut. Bull. 162, 111883 https://doi.org/10.1016/j.marpolbul.2020.111883.
Andrade, G.E., 2022. A response to cultural arguments in the renewed disputes over the ethics of bullfighting. Sport Ethics Philos. 16 (1), 50–65. https://doi.org/10.1080/17511321.2021.188733.
Berr, T., Naudet, J., Lagourgue, C., Vuibert, K., Bourgeois, K., Vidal, E., 2020. Plastic ingestion by seabirds in New Caledonia, South Pacific. Mar. Pollut. Bull. 152, 110925 https://doi.org/10.1016/j.marpolbul.2020.110925f.
Bhanot, S.P., 2021. Isolating the effect of injunctive norms on conservation behavior: new evidence from a field experiment in California. Organ. Behav. Hum. Decis. Process. 163, 30–42. https://doi.org/10.1016/j.obhdp.2018.11.002.
Borrelle, S.B., Ringma, J., Law, K.L., Monnahan, C.C., Lebreton, L., Mcgivern, A., Murphy, E., Jambeck, J., Leonard, G.H., Hilleary, M.A., Eriksen, M., Possingham, H. P., de Frond, H., Gerber, L.R., Polidoro, B., Tahir, A., Bernard, M., Mallos, N., Barnes, M., Rochman, C.M., 2020. Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. Science 369 (6510), 1515–1518. https://doi.org/10.1016/j.obhdp.2018.11.00210.1126/science.aba3656.
Burrows, S.D., Ribeiro, F., O'Brien, S., Okoffo, E., Toapanta, T., Charlton, N., Kaserzon, S., Lin, C.-Y., Tang, C., Rauert, C., Wang, X., Shimko, K., O'Brien, J., Townsend, P.A., Grayson, M.N., Galloway, T., Thomas, K.V., 2022. The message on the bottle: rethinking plastic labelling to better encourage sustainable use. Environ. Sci. Pol. 132, 109–118. https://doi.org/10.1016/j.envsci.2022.02.015.
Byerly, H., Balmford, A., Ferraro, P.J., Wagner, C.H., Palchak, E., Polasky, S., Ricketts, T. H., Schwartz, A.J., Fisher, B., 2018. Nudging pro-environmental behavior: evidence and opportunities. Front. Ecol. Environ. 16 (3), 159–168. https://doi.org/10.1002/fee.1777.
Cammalieri, V., Marotta, D., Antonucci, A., Protano, C., Fara, G.M., 2020. A survey of knowledge & awareness on the issue "microplastics": a pilot study in a sample of future public health professionals. Ann. Ig. 32 (5), 577–589. https://doi.org/10.1007/978-3-319-61615-5_11.
Cappa, F., Rosso, F., Giustiniano, L., Porfiri, M., 2020. Nudging and citizen science: the effectiveness of feedback in energy-demand management. J. Environ. Manag. 269, 110759 https://doi.org/10.1016/j.jenvman.2020.110759.
Catarino, A.I., Kramm, J., Völker, C., Henry, T.B., Everaert, G., 2021. Risk posed by microplastics: scientific evidence and public perception. Curr. Opin. Green Sustain. Chem. 29, 100467 https://doi.org/10.1016/j.cogsc.2021.100467.
Chang, M., 2015. Reducing microplastics from facial exfoliating cleansers in wastewater through treatment versus consumer product decisions. Mar. Pollut. Bull. 101 (1), 330–333. https://doi.org/10.1016/j.marpolbul.2015.10.074.
Chen, M.F., 2016. Impact of fear appeals on pro-environmental behavior and crucial determinants. Int. J. Advert. 35 (1), 74–92. https://doi.org/10.1080/02650487.2015.1101908.
Chen, J., Wu, J., Sherrell, P.C., Chen, J., Wang, H., Zhang, W., Yang, J., 2022. How to build a microplastics-free environment: strategies for microplastics degradation and plastics recycling. Adv. Sci. 9, 2103764. https://doi.org/10.1002/advs.202103764.
Christensen, P.R., Scheuermann, A.M., Loeffler, K.E., Helms, B.A., 2019. Closed-loop recycling of plastics enabled by dynamic covalent diketoenamine bonds. Nat. Chem. 11, 442–448. https://doi.org/10.1038/s41557-019-0249-2.
Deme, G.G., Ewusi-Mensah, D., Olagbaju, O.A., Okeke, E.S., Okoye, C.O., Odii, E.C., Sanganyado, E., 2022. Macro problems from microplastics: toward a sustainable policy framework for managing microplastic waste in Africa. Sci. Total Environ. 804, 150170 https://doi.org/10.1016/j.scitotenv.2021.150170.
Deng, L., Cai, L., Sun, F., Li, G., Che, Y., 2020. Public attitudes towards microplastics: perceptions, behaviors and policy implications. Resour. Conserv. Recycl. 163, 105096 https://doi.org/10.1016/j.resconrec.2020.105096.
Didegah, F., Mejlgaard, N., Sørensen, M.P., 2018. Investigating the quality of interactions and public engagement around scientific papers on twitter. J. Inf. Secur. 12, 960–971. https://doi.org/10.1016/j.joi.2018.08.002.
Engel, M.T., Vaske, J.J., Bath, A.J., 2021. Ocean imagery relates to an individual's cognitions and pro-environmental behaviours. J. Environ. Psychol. 74, 101588 https://doi.org/10.1016/j.jenvp.2021.101588.
Escario, J.-J., Rodriguez-Sanchez, C., Casaló, L.V., 2020. The influence of environmental attitudes and perceived effectiveness on recycling, reducing, and reusing packaging materials in Spain. Waste Manag. 113, 251–260. https://doi.org/10.1016/j.wasman.2020.05.043.
Gao, Y., Liu, Y., 2022. Removal of microplastics by coagulation treatment in waters and prospect of recycling of separated microplastics: a mini-review. J. Environ. Chem. Eng. 10 (5), 108197 https://doi.org/10.1016/j.jece.2022.108197.

Garcia-Vazquez, E., Carton, P., Dominguez, M., Rodriguez, N., Bustillos, A., Dopico, E., 2021. *For a good selfie*. Enhancing mobile phone recycling through simulated exposure to cobalt mining. Sustain. Prod. Consum. 26, 44–53. https://doi.org/10.1016/j.spc.2020.09.012.

Garcia-Vazquez, E., Garcia-Ael, C., Mesa, M.L.C., Dopico, E., Rodriguez, N., 2022. Enhancing marine citizenship as a strategy to promote the reduction of single-use plastics consumption in different cultures. Front. Mar. Sci. 9, 941694 https://doi.org/10.3389/fmars.2022.941694.

Garcia-Vazquez, E., Garcia-Ael, C., Mesa, M.L.C., Rodriguez, N., Dopico, E., 2023. Greater willingness to reduce microplastics consumption in Mexico than in Spain supports the importance of legislation about the use of plastics. Front. Psychol. 13, 1027336. https://doi.org/10.3389/fpsyg.2022.1027336.

GESAMP, 2019. In: Kershaw, P.J., Turra, A., Galgani, F. (Eds.), Guidelines or the Monitoring and Assessment of Plastic Litter and Microplastics in the Ocean, No. 99. (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP, p. 130.

GESAMP Reports and Studies, 2016. In: Kershaw, P.J., Rochman, C.M. (Eds.), Sources, Fate and Effects of Microplastics in the Marine Environment: Part Two of a Global Assessment, p. 220. http://www.gesamp.org/data/gesamp/files/file_element/220c250c023936f023937ffd016506be023330b023943c023956/rs023993e.pdf.

Grant, M.L., Lavers, J.L., Hutton, I., Bond, A.L., 2021. Seabird breeding islands as sinks for marine plastic debris. Environ. Pollut. 276, 116734 https://doi.org/10.1016/j.envpol.2021.116734.

Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001. PAST: paleontological statistics software package for education and data analysis. Palaeontol. Electron. 4 (1), 1. https://palaeo-electronica.org/2001_1/past/issue1_01.htm.

Heller, M.C., Mazor, M.H., Keoleian, G.A., 2020. Plastics in the US: toward a material flow characterization of production, markets and end of life. Environ. Res. Lett. 15 (9), 094034 https://doi.org/10.1088/1748-9326/ab9e1e.

Hunt, C.F., Lin, W.H., Voulvoulis, N., 2021. Evaluating alternatives to plastic microbeads in cosmetics. Nat. Sustain. 4 (4), 366–372. https://doi.org/10.1038/s41893-020-00651-w.

Jeong, D., Yoon, A., Chon, J., 2021. The impact of the perceived risk and conservation commitment of marine microplastics on tourists' pro-environmental behaviors. Sci. Total Environ. 774, 144782 https://doi.org/10.1016/j.scitotenv.2020.144782.

Johansen, M.R., Christensen, T.B., Ramos, T.M., Syberg, K., 2022. A review of the plastic value chain from a circular economy perspective. J. Environ. Manag. 302 (A), 113975 https://doi.org/10.1016/j.jenvman.2021.113975.

Khan, F., Ahmed, W., Najmi, A., 2019. Understanding consumers' behavior intentions towards dealing with the plastic waste: perspective of a developing country. Resour. Conserv. Recycl. 142, 49–58. https://doi.org/10.1016/j.resconrec.2018.11.020.

Kim, A.A., Sadatsafavi, H., Medal, L., Ostergren, M.J., 2018. Impact of communication sources for achieving campus sustainability. Resour. Conserv. Recycl. 139, 366–376. https://doi.org/10.1016/j.resconrec.2018.08.024.

Kühn, S., van Franeker, J.A., 2020. Quantitative overview of marine debris ingested by marine megafauna. Mar. Pollut. Bull. 151, 110858 https://doi.org/10.1016/j.marpolbul.2019.110858.

Law, K.L., Starr, N., Siegler, T.R., Jambeck, J.R., Mallos, N.J., Leonard, G.H., 2020. The United States' contribution of plastic waste to land and ocean. Sci. Adv. 6 (44), eabd0288. https://doi.org/10.1126/sciadv.abd0288.

Levine, M., Ensom, M.H., 2001. Post hoc power analysis: an idea whose time has passed? Pharmacotherapy 21 (4), 405–409. https://doi.org/10.1592/phco.21.5.405.34503.

Lieske, D.J., McFarlane Tranquilla, L., Ronconi, R., Abbott, S., 2019. Synthesizing expert opinion to assess the at-sea risks to seabirds in the western North Atlantic. Biol. Conserv. 233, 41–50. https://doi.org/10.1016/j.biocon.2019.02.026.

Linder, N., Lindahl, T., Borgström, S., 2018. Using behavioural insights to promote food waste recycling in urban households—evidence from a longitudinal field experiment. Front. Psychol. 9, 352. https://doi.org/10.3389/fpsyg.2018.00352.

Luo, Y., Douglas, J., Pahl, S., Zhao, J., 2022. Reducing plastic waste by visualizing marine consequences. Environ. Behav. 54 (4), 809–832. https://doi.org/10.1177/00139165221090154.

McIlwraith, H.K., Kim, J., Helm, P., Bhavsar, S.P., Metzger, J.S., Rochman, C.M., 2021. Evidence of microplastic translocation in wild-caught fish and implications for microplastic accumulation dynamics in food webs. Environ. Sci. Technol. 55 (18), 12372–12382. https://doi.org/10.1021/acs.est.1c02922.

Mitrano, D.M., Wohlleben, W., 2020. Microplastic regulation should be more precise to incentivize both innovation and environmental safety. Nat. Commun. 11 (1), 1–12. https://doi.org/10.1038/s41467-020-19069-1.

Nuojua, S., Pahl, S., Thompson, R., 2022. Ocean connectedness and consumer responses to single-use packaging. J. Environ. Psychol. 81, 101814 https://doi.org/10.1016/j.jenvp.2022.101814.

Pejman, N., Kallas, Z., Dalmau, A., Velarde, A., 2019. Should animal welfare regulations be more restrictive? A case study in eight European Union countries. Animals 9 (4), 195. https://doi.org/10.3390/ani9040195.

Rahimi, A., García, J.M., 2017. Chemical recycling of waste plastics for new materials production. Nat. Rev. Chem. 1 (6), 1–11. https://doi.org/10.1038/s41570-017-0046.

Rausch, T.M., Kopplin, C.S., 2021. Bridge the gap: Consumers' purchase intention and behavior regarding sustainable clothing. J. Clean. Prod. 278, 123882 https://doi.org/10.1016/j.jclepro.2020.123882.

Razzini, K., Castrica, M., Menchetti, L., et al., 2020. SARS-CoV-2 RNA detection in the air and on surfaces in the COVID-19 ward of a hospital in Milan, Italy. Sci. Total Environ. 742, 140540 https://doi.org/10.1016/j.scitotenv.2020.140540.

Reed, M.R., Chen, W.-T., 2022. Plastics crash course: a website for teaching plastics recycling and microplastics prevention through infographics. Recycling 7, 65. https://doi.org/10.3390/recycling7050065.

Reike, D., Vermeulen, W.J.V., Witjes, S., 2018. The circular economy: new or refurbished as CE 3.0? — exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resour. Conserv. Recycl. 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027.

Rodrigues, M.O., Abrantes, N., Gonçalves, F.J.M., Nogueira, H., Marques, J.C., Gonçalves, A.M.M., 2019. Impacts of plastic products used in daily life on the environment and human health: what is known? Environ. Toxicol. Pharmacol. 72, 103239 https://doi.org/10.1016/j.etap.2019.103239.

Rosseto, M., Krein, D.D., Balbé, N.P., Dettmer, A., 2019. Starch–gelatin film as an alternative to the use of plastics in agriculture: a review. J. Sci. Food Agric. 99, 6671–6679. https://doi.org/10.1002/jsfa.9944.

Ruggero, F., Gori, R., Lubello, C., 2020. Methodologies for microplastics recovery and identification in heterogeneous solid matrices: a review. J. Polym. Environ. 28 (3), 739–748. https://doi.org/10.1007/s10924-019-01644-3.

SAPEA, Science Advice for Policy by European Academies, 2019. A Scientific Perspective on Microplastics in Nature and Society. SAPEA, Berlin. https://doi.org/10.26356/microplastics.

Soares, J., Miguel, I., Venâncio, C., Lopes, I., Oliveira, M., 2021. Public views on plastic pollution: knowledge, perceived impacts, and pro-environmental behaviours. J. Hazard. Mater. 412, 125227 https://doi.org/10.1016/j.jhazmat.2021.125227.

Soutter, A.R.B., Boag, S., 2019. Environmental advertising: the effect of imagery on pro-environmental attitudes and pro-environmental behaviour/Publicidad medioambiental: el efecto de las imágenes sobre las actitudes proambientales y el comportamiento proambiental. PsyEcology 10 (1), 88–126. https://doi.org/10.1080/21711976.2018.1550238.

Sullivan, K.P., Werner, A.Z., Ramirez, K.J., et al., 2022. Mixed plastics waste valorization through tandem chemical oxidation and biological funneling. Science 378, 207–211. https://doi.org/10.1126/science.abo4626.

Tournier, V., Topham, C.M., Gilles, A., et al., 2020. An engineered PET depolymerase to break down and recycle plastic bottles. Nature 580, 216–219. https://doi.org/10.1038/s41586-020-2149-4.

Valerio, M.A., Rodriguez, N., Winkler, P., Lopez, J., Dennison, M., Liang, Y., et al., 2016. Comparing two sampling methods to engage hard-to-reach communities in research priority setting. BMC Med. Res. Methodol. 16, 146. https://doi.org/10.1186/s12874-016-0242-z.

Van Franeker, J.A., Meijboom, A., 2002. *Litter NSV - Marine Litter Monitoring by Northern Fulmars: A Pilot Study*. ALTERRA-Rapport 401, Wageningen, Alterra (2002), p. 72. http://edepot.wur.nl/45695.

Vicente-Molina, M.A., Fernández-Sainz, A., Izagirre-Olaizola, J., 2018. Does gender make a difference in pro-environmental behavior? The case of the Basque Country University students. J. Clean. Prod. 176, 89–98. https://doi.org/10.1016/j.jclepro.2017.12.079.

Völker, C., Kramm, J., Wagner, M., 2019. On the creation of risk: framing of microplastics risks in science and media. Global Chall. 4, 1900010. https://doi.org/10.1002/gch2.201900010.

Wee, S.-C., Choong, W.-W., Low, S.-T., 2021. Can "nudging" play a role to promote pro-environmental behaviour? Environ. Challenges 5, 100364. https://doi.org/10.1016/j.envc.2021.100364.

Whitley, C.T., Kalof, L., Flach, T., 2021. Using animal portraiture to activate emotional affect. Environ. Behav. 53 (8), 837–863. https://doi.org/10.1177/0013916520928429.

Wolstenholme, E., Poortinga, W., Whitmarsh, L., 2020. Two birds, one stone: the effectiveness of health and environmental messages to reduce meat consumption and encourage pro-environmental behavioral spillover. Front. Psychol. 11, 577111 https://doi.org/10.3389/fpsyg.2020.577111.

Wu, S.J., Paluck, E.L., 2021. Designing nudges for the context: golden coin decals nudge workplace behavior in China. Organ. Behav. Hum. Decis. Process. 163, 43–50. https://doi.org/10.1016/j.obhdp.2018.10.002.

Xiao, C., McCright, A.M., 2015. Gender differences in environmental concern: revisiting the institutional trust hypothesis in the USA. Environ. Behav. 47 (1), 17–37. https://doi.org/10.1177/0013916513491571.

Xiao, Y., Liu, X., Ren, T., 2022. Internet use and pro-environmental behavior: evidence from China. PLoS One 17 (1), e0262644. https://doi.org/10.1371/journal.pone.0262644.

Yadav, S.S., Kar, S.K., Rai, P.K., 2022. Why do consumers buy recycled shoes? An amalgamation of the theory of reasoned action and the theory of planned behaviour. Front. Environ. Sci. 10, 1007959. https://doi.org/10.3389/fenvs.2022.1007959.

Yoon, A., Jeong, D., Chon, J., 2021. The impact of the risk perception of ocean microplastics on tourists' pro-environmental behavior intention. Sci. Total Environ. 774, 144782 https://doi.org/10.1016/j.scitotenv.2020.144782.

Yuan, Z., Nag, R., Cummins, E., 2022. Human health concerns regarding microplastics in the aquatic environment - from marine to food systems. Sci. Total Environ. 823, 153730 https://doi.org/10.1016/j.scitotenv.2022.153730.

Yurtsever, M., 2019. Glitters as a source of primary microplastics: an approach to environmental responsibility and ethics. J. Agric. Environ. Ethics 32 (23), 459–478. https://doi.org/10.1007/s10806-019-09785-0.

Zhang, S., Wang, J., Liu, X., Qu, F., Wang, X., Wang, X., Li, Y., Sun, Y., 2019. Microplastics in the environment: a review of analytical methods, distribution, and biological effects. TrAC Trends Anal. Chem. 111, 62–72. https://doi.org/10.1016/j.trac.2018.12.002.