

1 **Mixed evidence for the effect of virtual nature exposure on effortful pro-environmental**
2 **behavior**

3 Florian Lange¹ & Maarten Truyens²

4 ¹Behavioral Economics and Engineering Group, Faculty of Economics and Business, KU
5 Leuven

6 ²Faculty of Economics and Business, KU Leuven

7
8 *Correspondence:*

9 *Florian Lange*

10 *BEE – Behavioral Economics and Engineering Group*

11 *KU Leuven*

12 *Naamsestraat 69*

13 *3000 Leuven,*

14 *Belgium*

15 *florian.lange@kuleuven.be*

16

17 This manuscript has been accepted for publication in the *Journal of Environmental*

18 *Psychology* at 2 April 2022 and the final version of the article is available at

19 <https://doi.org/10.1016/j.jenvp.2022.101803>.

20

21 **Acknowledgements**

22 This project was supported by a FWO postdoctoral fellowship (No 12U1221N)

23 awarded to Florian Lange. The authors thank Dominique Troost for providing us with the

24 neutral control video used in Study 2.

25

Abstract

26

27

28

29

30

31

32

33

34

35

36

37

38

39

40

41

42

43

Exposure to (virtual) nature may play a critical role in the promotion of pro-environmental behavior. Prior experimental work presenting participants with natural scenes has produced promising, but not fully conclusive results. Here, we studied the effect of virtual nature exposure on performance in a validated and fully consequential experimental model of effortful pro-environmental behavior. In Study 1, participants ($N = 256$) watched a video featuring either natural or urban scenes before completing the Work for Environmental Protection Task. Participants watching the nature video spent more pro-environmental effort on that task than participants watching the urban video. However, we were not able to distinguish if this difference resulted from a positive effect of nature exposure or from a negative effect of watching the urban video. To address this limitation, we designed a second study ($N = 803$) involving additional control conditions. Study 2 did not find the nature video to significantly promote effortful pro-environmental behavior in comparison to watching a neutral video or no video at all, nor did it replicate the nature-urban difference found in Study 1. The available evidence is compatible with the effect of virtual nature exposure on (effortful) pro-environmental behavior being either small, null, or moderated by methodological differences between the studies.

Keywords: nature exposure; natural environments; pro-environmental behavior; prosocial behavior; behavioral assessment; Work for Environmental Protection Task (WEPT)

44

1. Introduction

45

46

47

48

49

50

51

52

53

54

55

56

57

58

59

60

61

62

63

64

65

66

67

68

Being exposed to nature has been linked to a number of psychological benefits (Bratman et al., 2019; Hartig et al., 2014; Schertz & Berman, 2019). In addition, nature exposure may play a critical role in the promotion of pro-environmental behavior. When in nature, people have the opportunity to experience the benefits and rewarding properties that natural environments can provide. They may notice the relaxing effect of a hike through the woods or the beauty of natural scenes. Such beneficial experiences may cause them to appreciate nature and this appreciation can manifest itself in multiple ways: people may experience positively valenced emotions (MacMahan & Estes 2015), report a stronger sense of connection to nature (Mayer et al., 2009), and seek to repeat the rewarding nature experience. Importantly, they may also engage in activities that protect the object of their appreciation (Dunlap & Heffernan, 1975; Kaiser et al., 2013). In line with this notion, several studies have found positive correlations between nature exposure and self-reported pro-environmental behavior (e.g., Byrka et al., 2010; Collado et al., 2015; Nord et al., 1998; Martin et al., 2020; Whitburn et al., 2019).

To address the typical limitations of correlational self-report studies (Lange et al., 2018), other researchers have studied the effect of manipulated exposure to virtual nature on pro-environmental behavior in the laboratory. Studies adopting this approach have generated promising results. Having watched a nature documentary, participants in the study by Arendt and Matthes (2016) donated more money to environmental organizations (vs. control organizations unrelated to nature) compared to a control group who had watched a documentary about Einstein's Theory of Relativity. Similarly, watching a documentary about dolphins (vs. bridges) shifted donations toward the conservation of dolphins (vs. bridges) in the study by Janpol and Dilts (2016). Moreover, watching videos featuring natural versus built environments led to more sustainable behavior in a fishing-themed commons dilemma

69 (Zelenski et al., 2015). However, the conclusiveness of these previous experimental studies is
70 limited by a number of factors.

71 First, effects of experimental nature exposure on pro-environmental behavior have not
72 consistently been replicated. Watching a video depicting natural landscapes (vs. urban scenes)
73 did not significantly promote paper saving and environmental information seeking in the
74 study by Soliman and colleagues (2017) or donations to an environmental organization in the
75 studies by Klein and Hilbig (2018). Similarly, the nature video used by Franzen and Mader
76 (2020) did not increase pro-environmental donation behavior in comparison to a no-video
77 control condition.

78 Second, previous studies on the effect of nature exposure have been restricted to a
79 narrow range of experimental models (i.e., arranged situations that allow observing
80 consequential behavior under controlled conditions). Most of these studies examined financial
81 decisions of environmental relevance and no study required participants to make an actual
82 effort to benefit the environment. This limitation may be problematic given that some
83 accounts of nature exposure effects would predict the effect to be particularly pronounced for
84 effortful pro-environmental behaviors (e.g., picking up litter or cycling to a distant organic
85 store). Nature exposure has repeatedly been reported to improve performance on effortful
86 cognitive tasks (Stevenson et al., 2018). Such findings are typically interpreted as evidence
87 for nature-related cognitive enhancement (e.g., Kaplan, 1995; Schertz & Berman, 2019), but
88 may also reflect more general, motivational processes (Joye et al., under review). People
89 generally prefer exposure to natural (vs. urban) scenes (Meidenbauer et al., 2020), that is,
90 watching nature scenes seems to be relatively pleasant and rewarding. Having engaged in a
91 rewarding activity, individuals may be less likely to seek additional rewards and more likely
92 to engage in effortful or intrinsically unrewarding activities (Joye et al., under review; see also
93 Inzlicht & Schmeichel, 2012). By this means, watching aesthetically pleasing nature scenes

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

94 may promote effort expenditure (and thus performance) on cognitive tasks, but also effortful
95 pro-environmental behavior. In contrast, this hypothetical motivating potential of nature
96 exposure would likely be irrelevant for non-effortful pro-environmental behaviors that
97 primarily involve financial consequences. An increased likelihood to tolerate behavioral costs
98 (e.g., effort) can only manifest itself on behaviors that involve these costs and may not be
99 detectable using the typical financial donation tasks used in the literature on nature exposure
100 effects. Testing this domain-general motivational account and contrasting it with the
101 prevailing nature-specific account (i.e., the view that nature-exposure effects reflect increased
102 appreciation of nature following experience of its beneficial features) thus requires studies of
103 actually effortful pro-environmental behavior.

104 With the Work for Environmental Protection Task (WEPT), Lange and Dewitte (2022)
105 have recently developed and validated an experimental model of effortful pro-environmental
106 behavior. The WEPT involves repeated trade-offs between behavioral costs and
107 environmental benefits. Participants can choose to exert voluntary efforts on a tedious number
108 screening task and for every page of numbers they complete, a monetary donation is made to
109 an environmental organization. In support of its validity, WEPT performance was found to be
110 sensitive to the implemented costs and benefits and to be related to observations and self-
111 reports of other pro-environmental behaviors (Lange & Dewitte, 2021, 2022). By analyzing
112 WEPT performance after exposure to nature and control videos, we aimed to test whether
113 nature exposure can motivate people to incur actual behavioral costs for the actual benefit of
114 the environment.

115 While the WEPT has been developed for the study of pro-environmental behavior, the
116 procedure can flexibly be adapted to other domains. For example, by linking participants'
117 efforts on the task to donations to a prosocial (rather than environmental) organization, the
118 WEPT can be transformed into a prosocial behavior task. This versatility of the WEPT allows

119 testing two competing hypotheses regarding the specificity of nature-exposure effects.
120 According to the prevailing nature-specific account, strengthening of pro-environmental
121 behavior following nature exposure reflects increased appreciation of natural environments:
122 people act to protect nature because of having experienced that it is something worth
123 protecting. If this hypothesis holds true, nature exposure should promote effort expenditure
124 for the benefit of nature, but not for other goals. Alternatively, nature exposure may result in a
125 domain-general increase in effort expenditure. As outlined above, people may be more likely
126 to incur the behavioral costs of completing WEPT pages after having experienced the
127 rewarding properties of natural scenes. Such an increased tolerance towards costs would also
128 be consistent with previous studies observing more self-transcendent responding following
129 exposure to natural scenes (Castelo et al., 2021; Piff et al., 2015; Joye & Bolderdijk, 2015;
130 Joye et al., 2020). If the effect of nature exposure on pro-environmental behavior reflects a
131 domain-general increase in people's motivation or tolerance towards costs, nature exposure
132 should promote effort expenditure for the benefit of nature and other goals alike.

133 In the present studies, we used the experimental opportunities provided by the WEPT
134 to study the effect of virtual nature exposure on effortful pro-environmental behavior. While
135 Study 1 specifically aimed to dissociate the nature-specific and the domain-general account of
136 nature-exposure effects, Study 2 was a high-powered replication that involved additional
137 control conditions to address some of the limitations of Study 1. We confirm that we have
138 reported all experiments that we conducted on the effect of interest and that, for all
139 experiments, we reported all measures, conditions, data exclusions, and how we determined
140 our sample size. All data, analyses scripts, and materials are available at <https://osf.io/m9ruh/>.

141 **2. Study 1**

142 Study 1 was designed to contrast the nature-specific and the domain-general account
143 of nature-exposure effects on effortful pro-environmental behavior. To this end, we presented

144 participants with a video depicting either nature or urban scenes and then observed their
145 behavior on either a pro-environmental or prosocial version of the WEPT. Hypothesis 1 (i.e.,
146 the nature-specific account) predicted the effect of watching nature (vs. urban) videos on
147 WEPT performance to be specific to the environmental domain, that is, to be significantly
148 larger when participants complete the WEPT for a pro-environmental goal compared to a
149 prosocial goal. In contrast, Hypothesis 2 (i.e., the domain-general account) predicted virtual
150 nature exposure to enhance WEPT performance irrespective of whether the WEPT is
151 completed for a pro-environmental or prosocial goal.

152 **2.1 Methods**

153 Participants were recruited via the social media network of the last author and the
154 email list of the German Initiative for Environmental Protection, and encouraged to forward
155 the Qualtrics link to the online study. We preregistered to stop data collection after 400
156 participants had completed the study or after a maximum of 15 days. This stopping rule was
157 chosen for practical reasons (limited resources). After 15 days, 470 participants had been
158 reached, 192 of them did not proceed beyond the informed consent form. As preregistered, we
159 excluded participants who reported to be younger than 18 ($n = 7$) or who did not complete the
160 WEPT ($n = 15$), leaving an effective sample size of $N = 256$ (154 female, 100 male, one
161 preferred not to say, one did not provide demographic information). Participants' age ranged
162 from 18 to 77 ($M = 36.69$, $SD = 15.54$). All but two participants indicated to have a high
163 school degree and 76% indicated to currently pursue or to have obtained at least one college
164 degree. Sensitivity analyses revealed that, given $N = 256$ and $\alpha = .05$, effects of $f = 0.23$ (0.18)
165 could be detected with 95% (80%) power. Participants did not receive payment but generated
166 charitable donations of €147.40 through their efforts on the WEPT. The study was approved
167 by the local ethics committee (G-2020-2903-R2(MAR)). The study's preregistration is
168 available at <https://osf.io/7s26h>.

169 Participants were randomly assigned to watch a video featuring drone shots of either
170 natural ($n = 131$) or urban scenes ($n = 125$). The videos were of similar length (nature: 184 s,
171 urban: 199 s), accompanied by similar music, and compiled by the same creator. A within-
172 subject pilot study ($N = 38$) indicated that both videos were positively valenced, with the
173 nature video being more positively evaluated than the urban video (see Table S1 in the
174 Supplementary Materials). Participants were instructed to watch the video in full-screen mode
175 and with the sound turned on. To ensure that every participant spent a minimum amount of
176 time watching the video, we hid the button that allows proceeding to the next part of the study
177 for the first 30 s that participants spent on the video page.

178 Next, participants were introduced to the rules of number identification on the WEPT.
179 They were presented with 18 two-digit numbers and instructed to select all numbers with an
180 even first digit and an odd second digit. After completing this familiarization trial (with
181 corrective feedback, if required), participants were introduced to one of ten randomly drawn
182 charitable organizations and told that we would donate €0.10 to that organization if they
183 completed another page of 50 two-digit numbers at a sufficient level of accuracy. Following
184 this mandatory trial, the voluntary part of the WEPT began. Participants were asked (up to 15
185 times) if they wanted to complete another page of 50 numbers to generate a donation of €0.10.
186 When they declined this option for the first time (or accepted it for the 15th time), the WEPT
187 was finished and the number of completed WEPT pages (reflecting the amount of voluntary
188 effort participants made to generate donations) served as outcome measure for the task. A
189 WEPT page was counted as completed when the amount of time a participant spent on the
190 page was not more than two standard deviations below the sample mean for that page (0.2%
191 of all attempted pages were excluded based on this time-based criterion).

192 The charitable organization benefitting from a participant's effort on the WEPT was
193 drawn from one of two sets of five organizations: the pro-environmental set (WWF,

194 Greenpeace, FSC, Rainforest Alliance, Natuurpunt) or the prosocial set (UNICEF, Oxfam,
195 Amnesty International, Alzheimer Liga, Child Focus). These organizations were selected
196 based on a pilot study that asked $N = 38$ participants to rate ten environmental and ten
197 prosocial organizations with regard to knowledge of, trust in, and willingness to donate to the
198 organization. We selected the five environmental organizations that were rated highest across
199 these dimensions and attempted to find five prosocial organizations with similar ratings. This
200 matching procedure did not produce ideal results, but differences between the selected sets of
201 prosocial and environmental organizations were small overall (see Supplementary Table S2).
202 By randomly drawing an organization from these sets for each participant, we ensured that
203 potential differences between the pro-environmental and prosocial version of the WEPT were
204 not due to a specific organization.

205 After the WEPT, participants provided demographic data and were given the
206 opportunity to complete two exploratory self-report measures that are not reported in this
207 paper, but included in the dataset available at <https://osf.io/m9ruh/>. The proportion of
208 participants completing these additional measures (framed as help for another research
209 project) did not differ much between the nature video condition (62%) and the urban video
210 condition (61%).

211 2.2 Results

212 Participants completed an average of 5.46 ($SD = 5.88$) pages on the WEPT. A 2×2
213 ANOVA with the between-subjects factors Video Content (nature vs. urban) and WEPT
214 Version (pro-environmental vs. prosocial) revealed that participants completed more pages on
215 the prosocial ($M = 6.27$, $SD = 5.95$) than on the pro-environmental ($M = 4.60$, $SD = 5.70$)
216 version of the WEPT, $F(1, 252) = 5.59$, $p = .011$, $\eta_p^2 = .02$, 95% CI [.00, .06]. Overall, the
217 number of completed WEPT pages was not significantly higher after nature video exposure
218 ($M = 5.65$, $SD = 5.81$) than after urban video exposure ($M = 5.26$, $SD = 5.96$), $F(1, 252) =$

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

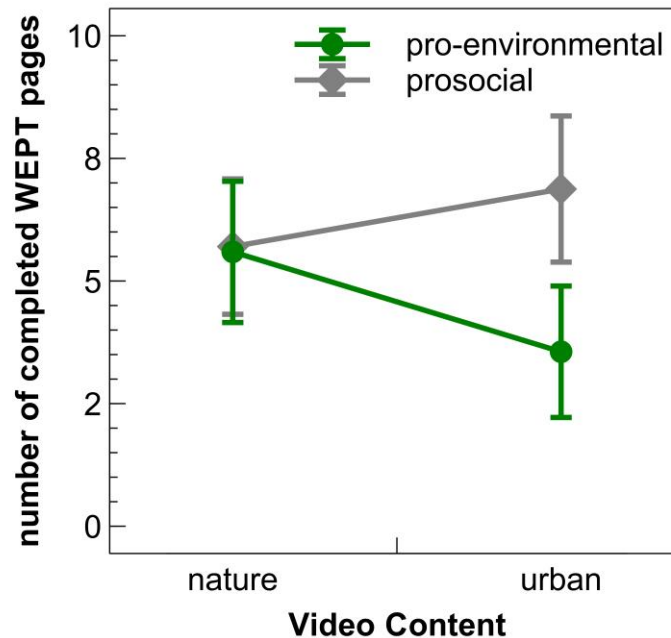
219 0.36, $p = .552$, $\eta_p^2 = .00$, 95% CI [.00, .02]. In contrast, the ANOVA revealed a significant
220 interaction between Video Content and WEPT Version, $F(1, 252) = 4.91$, $p = .028$, $\eta_p^2 = .02$,
221 95% CI [.00, .06]. For participants completing the WEPT for a pro-environmental
222 organization, watching the nature video ($n = 64$, $M = 5.59$, $SD = 5.89$) led to more completed
223 WEPT pages than watching the urban video ($n = 61$, $M = 3.56$, $SD = 5.34$), $t(123) = 2.03$, $p =$
224 $.045$, $d = 0.36$, 95% CI [0.01, 0.72]. A comparable t-test for participants completing the
225 prosocial WEPT version (nature: $n = 67$, urban: $n = 64$) was not significant, $t(129) = -1.13$, $p =$
226 $.261$, $d = -0.20$, 95% CI [-0.54, 0.15]. Hence, in accordance with Hypothesis 1, watching the
227 nature (vs. urban) video resulted in WEPT performance enhancement that was specific to the
228 pro-environmental version of the WEPT (Figure 1). As preregistered, we supplemented this
229 ANOVA with a Bayes Factor analysis using JASP default settings (JASP Team, 2020). This
230 analysis revealed anecdotal evidence ($BF_{10} = 1.91$) for the relative superiority of a model
231 including the interaction between Video Content and WEPT Version against a main-effects-
232 only model. In other words, the data were 1.91 times more likely under a model that adds the
233 interaction effect than under a main-effects-only model that does not.

234 In addition, we ran a series of non-preregistered exploratory robustness tests on the
235 critical interaction between Video Content and WEPT Version. The interaction remained
236 significant when we applied an alternative time-base criterion (i.e., spending at least 10
237 seconds on a page) for counting WEPT pages as completed, $F(1, 252) = 4.80$, $p = .029$, $\eta_p^2 =$
238 $.02$, or no criterion at all, $F(1, 252) = 5.04$, $p = .026$, $\eta_p^2 = .02$. Applying an accuracy-based
239 (rather than time-based) criterion for counting an WEPT page as completed did not markedly
240 change the results either. Requiring 90% of the target numbers to be correctly identified
241 excluded 174 (12%) of WEPT pages, but resulted in an interaction between Video Content
242 and WEPT Version of similar size, $F(1, 252) = 3.96$, $p = .048$, $\eta_p^2 = .02$. Requiring only 80%
243 of the target numbers to be correctly identified excluded 61 (4%) of WEPT pages and yielded

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

244 similar results as well, $F(1, 252) = 3.71, p = .055, \eta_p^2 = .02$. Similarly, results did not change
245 when excluding the 20 participants who were recruited via the email list of the German
246 Initiative for Environmental Protection, $F(1, 232) = 4.97, p = .027, \eta_p^2 = .02$. Finally, results
247 varied only slightly when excluding participants who spent less than 60 seconds, $F(1, 239) =$
248 $3.96, p = .048, \eta_p^2 = .02$, 120 seconds, $F(1, 224) = 3.20, p = .075, \eta_p^2 = .01$, or 180 seconds,
249 $F(1, 213) = 3.49, p = .063, \eta_p^2 = .02$, on the page displaying the video.

ACCEPTED MANUSCRIPT

250 **Figure 1**251 *Effect of nature exposure on pro-environmental and prosocial WEPT performance in Study 1*

252

253 *Note.* WEPT = Work for Environmental Protection Task. Vertical bars are 95% confidence
 254 intervals.

255

256 **2.3 Discussion**

257 The significant interaction between Video Content and WEPT Version found in Study

258 1 seems to support Hypothesis 1. Watching a nature vs. urban video only affected

259 participants' behavior when they completed the WEPT for the benefit of a pro-environmental

260 organization and the effect did not extend to effort expenditure for prosocial organizations.

261 This pattern of results may be taken to indicate that nature exposure effects on pro-

262 environmental behavior reflect domain-specific (i.e., increased caring for environmental

263 protection) rather than domain-general processes (i.e., enhanced motivation, tolerance of

264 behavioral costs, or self-transcendence). It also illustrates the experimental opportunities

265 provided by the WEPT. By manipulating nothing but the organization linked to participants'

291 video (Hypothesis 2) and whether watching the urban video would reduce WEPT
292 performance in comparison to these control conditions (Hypothesis 3).

293 **3.1 Methods**

294 Sample-size planning for Study 2 was based on the difference between the nature
295 video condition and the urban video condition observed in Study 1 ($d = 0.36$). Power analysis
296 (G*Power 3.1.9.2, Faul et al., 2007) indicated that 168 participants per condition are required
297 to detect effects of $d = 0.36$ or larger at a statistical power of 95% in one-sided group
298 comparisons ($\alpha = .05$). We rounded that number to a target sample size of $n = 200$ per
299 condition or $N = 800$ in total.

300 Participants were recruited from the online data-collection platform Prolific. The study
301 was advertised to Prolific users who a) named the UK as their current country of residence, b)
302 indicated to be fluent in English, and c) did not participate in any prior WEPT studies from
303 our group (i.e., about 43,000 active users). The study was activated on a Wednesday evening
304 in December 2021, the target sample size was reached after approximately three hours, and all
305 participants completed the study on that same evening. One participant completed the WEPT
306 but not the entire study and two participants were timed out before returning to Prolific after
307 the study. These three participants did not count towards the sample size in Prolific, but they
308 met our preregistered inclusion criteria. Hence, total sample size for Study 2 was $N = 803$.
309 Participants received £1.50 for their participation and their performance within the experiment
310 generated pro-environmental donations of £406.20. The study was approved by the local
311 ethics committee (G-2020-2903-R3(AMD)). The study's preregistration is available at
312 <https://osf.io/qcptz>.

313 Of the total sample, 523 participants identified as female, 268 as male, five preferred
314 not to say, six preferred to self-describe (four as non-binary, one as genderqueer, and one as
315 binary), and one did not provide demographic information. Age ranged from 18 to 84 years

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

316 ($M = 39.96$, $SD = 14.91$). Most participants indicated to be employed full-time (41%) or part-
317 time (17%); 12% were students, 12% unemployed, 9% retired, 7% preferred to self-describe
318 their professional status (homemaker: 3%, self-employed = 1%, disabled = 1%, multiple/other
319 = 2%), and 2% preferred not to say.

320 After having provided informed consent, participants were randomly allocated to watch
321 either the nature video used in Study 1, the urban video used in Study 1, a neutral control video
322 showing a carpenter working on a plank of wood (duration = 193 s, accompanied by the same
323 music as used for the urban video), or no video. In the conditions involving a video, participants
324 were instructed to watch the entire video at normal speed, in full-screen mode, and with the
325 volume turned on. The button that allows proceeding to the next part of the study was hidden
326 for the first 60 s that participants spent on the video page. Participants then completed the WEPT
327 version used in Study 1 for a randomly chosen environmental organization (WWF, Greenpeace,
328 FSC, Rainforest Alliance, or Natuurpunt). In contrast to Study 1, completing WEPT pages led
329 to donations of £0.10 rather than €0.10. To evaluate Hypotheses 1-3, we compared the number
330 of completed WEPT pages (i.e., the number of pages on which page completion times were not
331 more than two standard deviations below the sample mean) across video conditions using one-
332 sided Welch's t-tests against a significance level of $\alpha = .05$.

333 After the WEPT, participants completed a number of exploratory measures administered
334 to further elucidate the effect of the video. They first completed the International Positive and
335 Negative Affect Schedule Short Form (I-PANAS-SF, Thompson, 2007) before rating the
336 WEPT on a number of dimensions (*fun, tiring, boring, enjoyable, pleasurable, effortful, easy,*
337 *mentally challenging, difficult to understand, clearly explained*). Next, participants in all
338 conditions except for the no-video condition were asked to rate the video (*good quality,*
339 *interesting, amusing, exciting, neutral, positive*) and to indicate what/how they felt while
340 watching the video (*awe, bored, happy, sad, small and insignificant*). All participants then

341 completed the Reward Responsiveness subscale of the Behavioral Approach System Scale (α
342 = .82, Carver & White, 1994; example item: “When good things happen to me, it affects me
343 strongly.”) and the Natural Beauty ($\alpha = .84$) and Artistic Beauty ($\alpha = .89$) subscales from the
344 Engagement with Beauty Scale (Diessner et al., 2008; example item: “I notice beauty in one or
345 more aspects of nature/in art and human made objects.”). Finally, participants indicated, for
346 each of the five environmental organizations used as receiving organizations for the WEPT, to
347 which extent they knew the organization, trusted the organization, and were willing to donate
348 to this organization before providing basic demographic data.

349 **3.2 Results**

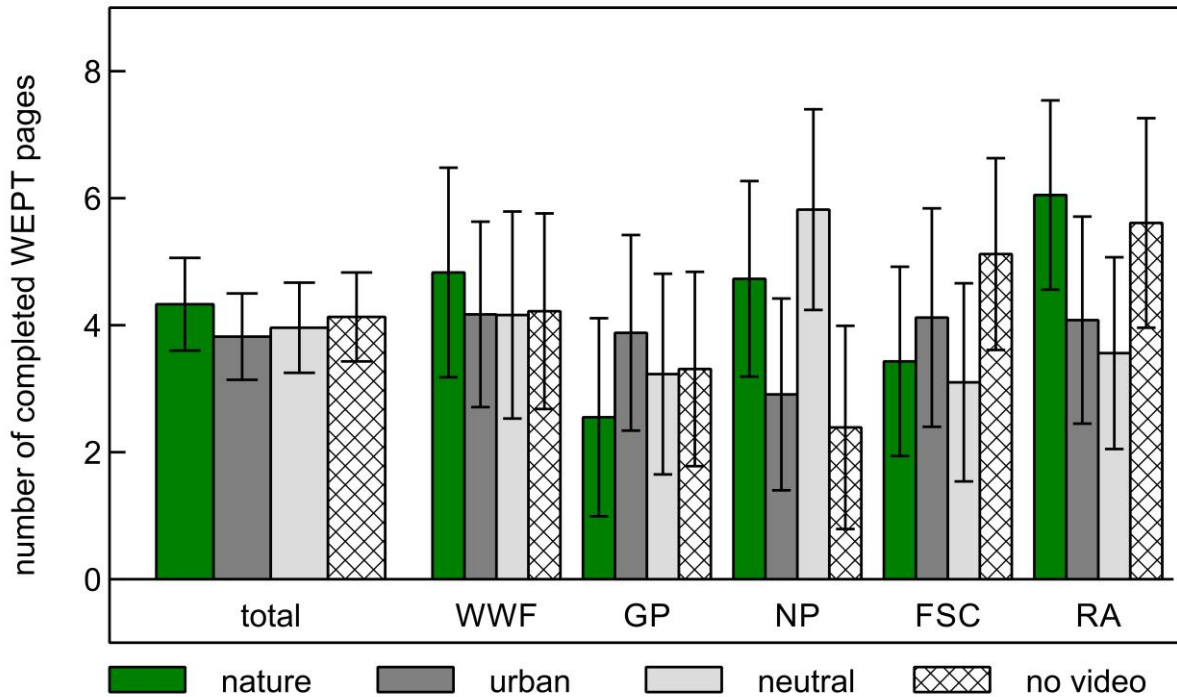
350 Participants completed an average of 4.06 ($SD = 5.09$) pages on the WEPT and we did
351 not have to exclude any pages based on our time-based exclusion criterion. The number of
352 completed WEPT pages was largest when participants completed the WEPT for the benefit of
353 the Rainforest Alliance ($M = 4.83$, $SD = 5.70$, $n = 160$), followed by WWF ($M = 4.33$, $SD =$
354 5.17 , $n = 160$), Natuurpunt ($M = 3.96$, $SD = 4.98$, $n = 161$), FSC ($M = 3.94$, $SD = 4.77$, $n =$
355 160), and Greenpeace ($M = 3.25$, $SD = 4.70$, $n = 162$).

356 The difference in completed WEPT pages between the nature video condition ($M =$
357 4.33 , $SD = 5.32$) and the urban video condition ($M = 3.82$, $SD = 4.92$) was not statistically
358 significant, $t(401.84) = 1.01$, $p = .157$, $d = 0.10$, 95% CI [-0.10, 0.30], thus failing to support
359 Hypothesis 1 (see also Figure 2). Participants did not complete significantly more WEPT
360 pages in the nature video condition than in the neutral video condition ($M = 3.96$, $SD = 5.08$),
361 $t(400.95) = 0.71$, $p = .239$, $d = 0.07$, 95% CI [-0.13, 0.27], or in the no-video condition ($M =$
362 4.13 , $SD = 5.05$), $t(402.72) = 0.39$, $p = .348$, $d = 0.04$, 95% CI [-0.16, 0.23], either (cf.
363 Hypothesis 2). Similarly, we did not find conclusive support for Hypothesis 3 as the number
364 of WEPT pages was not significantly lower after watching the urban video than after
365 watching the neutral control video, $t(395.28) = -0.29$, $p = .387$, $d = -0.03$, 95% CI [-0.23,

366 0.17], or after watching no video at all, $t(397.70) = -0.62, p = .267, d = -0.06, 95\% \text{ CI} [-0.26,$
 367 0.13].

368 **Figure 2**

369 *WEPT performance in Study 2 as a function of video condition and organization*



370

371 *Note.* WEPT = Work for Environmental Protection Task. WEPT performance aggregated
 372 across all organizations is displayed in the leftmost group of bars (“total”). WWF = World
 373 Wide Fund for Nature, GP = Greenpeace, NP = Natuurpunt, FSC = Forest Stewardship
 374 Council, RA = Rainforest Alliance. Vertical bars are 95% confidence intervals.

375

376 We ran a number of non-preregistered, exploratory analyses to further inform the
 377 understanding of our results. A first analysis (see Supplementary Materials) indicated that the
 378 effect of our video manipulation may vary as a function of the organization that benefits from
 379 participants’ behavior on the WEPT (see Figure 2), but we did not find the pattern of results
 380 to be conclusive when adjusting for multiple comparisons.

381 Next, we explored whether results were affected by participants who skipped parts of
382 the video. On average, participants spent similar amounts of time on the video page in the
383 nature video condition ($M = 239$ s, $SD = 107$), the urban video condition ($M = 251$ s, $SD =$
384 96), and the neutral video condition ($M = 237$ s, $SD = 82$). Excluding participants who spent
385 less than 120 s on the video page (nature: $n = 2$, urban: $n = 4$, neutral: $n = 2$), or who spent
386 less than 180 s on that page (nature: $n = 4$, urban: $n = 8$, neutral: $n = 10$), did not markedly
387 change the results. The p values for all hypothesis tests remained non-significant and effect
388 sizes did not change by more than $d = 0.01$. Similar results were obtained when applying
389 accuracy-based criteria for counting WEPT pages as completed. In addition, we did not find
390 WEPT performance differences between the video conditions to be moderated by reward
391 responsiveness, $F(3, 795) = 2.12$, $p = .097$, engagement with natural beauty, $F(3, 794) = 0.12$,
392 $p = .947$, engagement with artistic beauty, $F(3, 794) = 0.13$, $p = .946$, age, $F(3, 794) = 0.14$, p
393 $= .937$, or gender (male vs. female), $F(3, 783) = 0.68$, $p = .566$.

394 To analyze whether the lack of support for our hypotheses might be due to insufficient
395 task comprehension, we analyzed participants' ratings of the WEPT (see Supplementary
396 Table S4). Across conditions, participants found the task to be clearly explained ($M = 3.73$,
397 median = 4, on a scale from 1 to 4) and to be not difficult to understand ($M = 1.27$, median =
398 1). Finally, we compared participants' video ratings across experimental conditions. In
399 general, the nature video was more positively evaluated than the urban video and the urban
400 video was more positively evaluated than the neutral video (see Supplementary Table S5).
401 The nature video was also rated to be awe-evoking ($M = 4.07$ on a scale from 1 to 5) and
402 happiness-inducing ($M = 3.93$). This pattern of results indicates that the lack of support for the
403 effectiveness of the nature video is unlikely to be related to a lack of positive valence.

404 **3.3 Discussion**

405 Study 2 did not generate conclusive evidence for either a positive effect of watching
406 nature videos or a negative effect of watching urban videos on effortful pro-environmental
407 behavior. In addition, we did not replicate the WEPT performance difference between the
408 nature and the urban video condition observed in Study 1, in spite of tripling the sample size
409 per condition.

410 **4. General Discussion**

411 While Study 1 found a WEPT performance difference between participants who
412 watched a nature vs. urban video, Study 2 did not replicate this effect nor did it find a
413 significant nature-related improvement in WEPT performance in comparison to the other two
414 control conditions. We thus have no conclusive evidence for the effect of nature exposure on
415 effortful pro-environmental behavior. One possible explanation for this pattern of results is
416 that the true effect of virtual nature exposure on effortful pro-environmental behavior (or on
417 pro-environmental behavior in general) is rather small (e.g., $d = 0.1$ or 0.2). Such an effect
418 size would be compatible with the findings of Study 1 and 2 (i.e., it is included in the
419 confidence intervals around the effects observed in those studies) and it might also account
420 for the mixed pattern of results observed in previous studies. Given the typical sample size
421 used in the field, a small true effect can be expected to produce a mix of significant (Study 1;
422 Arendt & Matthes, 2016; Janpol & Dilts, 2016; Zelenski et al., 2015) and non-significant
423 (Study 2; Franzen & Mader, 2020; Klein & Hilbig, 2018; Soliman et al., 2017) results. Even
424 our second study (the largest on the effect of nature exposure on pro-environmental behavior
425 thus far) did not have more than 64% (26%) power to detect an effect of $d = 0.2$ ($d = 0.1$). A
426 true effect of that size would not necessarily be meaningless. For example, the small effect (d
427 = 0.1) observed in Study 2 corresponded to half a WEPT page of a difference between the
428 nature and the urban video condition. By exerting this additional effort, participants in the
429 nature video condition generated 10 additional pounds of pro-environmental donations, a 13%

430 increase. While interventions that increase pro-environmental behavior by such a margin may
431 be of interest to the field of environmental psychology, studying them in a reliable way may
432 require substantially larger sample sizes.

433 Alternatively, it is also possible that methodological differences between the studies
434 caused the mixed pattern of significant and non-significant results. While the procedures of
435 Study 1 and Study 2 were highly similar, Study 2 recruited participants from a different
436 effective population (UK Prolific users) than Study 1 (the predominantly Belgian network of
437 one of the authors). Previous studies on the effect of nature exposure differed on multiple
438 dimensions as well (e.g., study population, operationalization of nature exposure, choice of
439 control condition, operationalization of pro-environmental behavior). Given that there are
440 likely more potentially meaningful moderator dimensions than studies on the effect, we do not
441 consider efforts to search for patterns in the published record to be very promising at this
442 point.

443 A third possibility to account for the results would be that the true effect of virtual
444 nature exposure on (effortful) pro-environmental behavior is zero. Findings as the one
445 presented in Study 1 may be false positives. At this point, the available evidence does not
446 allow to distinguish between the absence of an effect of virtual nature exposure and the
447 presence of a small effect. One way to address this issue would be a high-powered replication
448 effort that ideally combines multiple (or commonly agreed upon) operationalizations of nature
449 exposure and pro-environmental behavior. Given the scope of this task, it might best be
450 accomplished collectively, i.e., in a multi-lab replication project. Such multi-lab projects have
451 been proven useful in other fields of psychology to establish (or not) the presence and
452 robustness of an empirical phenomenon (McShane et al., 2019). Only after an effect (such as
453 the one of nature exposure on pro-environmental behavior) has been established as a robust
454 empirical phenomenon can it act as a meaningful constraint on psychological theories (Eronen

455 & Bringmann, 2021). We thus think that concerted efforts to establish the presence of nature
456 exposure effects on environmentally relevant outcomes would be a logical next step to
457 advance the field.

458 The present results should be interpreted in light of a number of limitations. Given that
459 our studies were conducted in an online setting, we did not have full experimental control
460 over the study environment. As a consequence, we could not make sure that participants
461 actually watched the videos used to manipulate nature exposure. However, we were able to
462 monitor how long participants stayed on the page displaying the videos, to ensure that all
463 participants spent a minimum amount of time on that page, and to verify that only few
464 participants skipped the video prematurely. Most importantly, results did not markedly change
465 when we excluded those participants who were arguably least motivated to watch the video
466 (i.e., those who skipped parts of it). Another limitation pertains to the external validity of our
467 results. While our sampling procedure produced some degree of diversity in our sample, we
468 did not randomly draw participants from the general population, which limits the
469 generalizability of our findings. Moreover, in line with other research in the field, we only
470 examined one specific way of exposing participants to virtual nature (i.e., one specific video)
471 and thus cannot exclude that characteristics specific to that video contributed to the observed
472 pattern of results. Finally, external validity depends on the degree to which relevant everyday
473 situations involve the same contingencies as our experimental model (Lange & Dewitte, 2019;
474 see also Klein & Hilbig, 2019). The WEPT has been demonstrated to involve a trade-off
475 between valued environmental benefits and time-consuming behavioral effort (Lange &
476 Dewitte, 2022) and this trade-off may be characteristic of many everyday pro-environmental
477 behaviors. However, other pro-environmental behaviors may involve other contingencies
478 (e.g., monetary costs) and are not necessarily affected by nature exposure in the same way as
479 WEPT performance. Future research focusing on other behaviors and experimental models

480 (e.g., Berger & Wyss, 2021; Klein et al., 2017; see Lange, 2022, for review) is needed to
481 examine the generality of potential nature effects on pro-environmental behavior.

ACCEPTED MANUSCRIPT

482

References

- 483 Arendt, F., & Matthes, J. (2016). Nature documentaries, connectedness to nature, and pro-
484 environmental behavior. *Environmental Communication, 10*, 453-472. doi:
485 10.1080/17524032.2014.993415
- 486 Berger, S., & Wyss, A. M. (2021). Measuring pro-environmental behavior using the carbon
487 emission task. *Journal of Environmental Psychology, 75*, 101613. doi:
488 10.1016/j.jenvp.2021.101613
- 489 Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., De Vries, S., Flanders, J., ... &
490 Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective.
491 *Science Advances, 5*, eaax0903. doi: 10.1126/sciadv.aax0903
- 492 Byrka, K., Hartig, T., & Kaiser, F. G. (2010). Environmental attitude as a mediator of the
493 relationship between psychological restoration in nature and self-reported ecological
494 behavior. *Psychological Reports, 107*, 847-859. doi: 10.2466/07.PRO.107.6.847-859
- 495 Castelo, N., White, K., & Goode, M. (2021). Exposure to nature promotes self-transcendence
496 and prosocial behavior. *Journal of Environmental Psychology, 76*, 101639.
497 10.1016/j.jenvp.2021.101639
- 498 Collado, S., Corraliza, J. A., Staats, H., & Ruiz, M. (2015). Effect of frequency and mode of
499 contact with nature on children's self-reported ecological behaviors. *Journal of*
500 *Environmental Psychology, 41*, 65-73. doi: 10.1016/j.jenvp.2014.11.001
- 501 Dunlap, R. E., & Heffernan, R. B. (1975). Outdoor recreation and environmental concern: An
502 empirical examination. *Rural Sociology, 40*, 18-30.
- 503 Eronen, M. I., & Bringmann, L. F. (2021). The theory crisis in psychology: How to move
504 forward. *Perspectives on Psychological Science, 17*45691620970586. doi:
505 10.1177/1745691620970586

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

- 506 Franzen, A., & Mader, S. (2020). Can Climate Skeptics Be Convinced? The Effect of Nature
507 Videos on Environmental Concern. *Sustainability*, *12*(7), 2972. doi:
508 10.3390/su12072972
- 509 Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and health. *Annual*
510 *Review of Public Health*, *35*, 207-228. doi: 10.1146/annurev-publhealth-032013-
511 182443
- 512 Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic
513 revision of the resource model of self-control. *Perspectives on Psychological Science*,
514 *7*(5), 450-463. doi: 10.1177/1745691612454134
- 515 Janpol, H. L., & Dilts, R. (2016). Does viewing documentary films affect environmental
516 perceptions and behaviors? *Applied Environmental Education & Communication*, *15*,
517 90-98. doi: 10.1080/1533015X.2016.1142197
- 518 JASP Team (2020). JASP (Version 0.14.1)[Computer software].
- 519 Joye, Y., & Bolderdijk, J. W. (2015). An exploratory study into the effects of extraordinary
520 nature on emotions, mood, and prosociality. *Frontiers in Psychology*, *5*, 1577. doi:
521 10.3389/fpsyg.2014.01577
- 522 Joye, Y., Bolderdijk, J. W., Köster, M. A., & Piff, P. K. (2020). A diminishment of desire:
523 Exposure to nature relative to urban environments dampens materialism. *Urban*
524 *Forestry & Urban Greening*, *54*, 126783. doi: 10.1016/j.ufug.2020.126783
- 525 Joye, Y., Lange, F., & Fischer, M. (under review). Does Beautiful Nature Motivate to Work?
526 Outlining an Alternative Pathway to Nature-Induced Cognitive Performance Benefits
527 and a Preregistered Test.
- 528 Kaiser, F. G., Hartig, T., Brügger, A., & Duvier, C. (2013). Environmental protection and
529 nature as distinct attitudinal objects: An application of the Campbell paradigm.
530 *Environment and Behavior*, *45*, 369-398. doi: 10.1177/0013916511422444

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

- 531 Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework.
532 *Journal of Environmental Psychology*, 15(3), 169-182. doi: 10.1016/0272-
533 4944(95)90001-2
- 534 Klein, S. A., & Hilbig, B. E. (2018). How virtual nature experiences can promote pro-
535 environmental behavior. *Journal of Environmental Psychology*, 60, 41-47. doi:
536 10.1016/j.jenvp.2018.10.001
- 537 Klein, S. A., & Hilbig, B. E. (2019). On the lack of real consequences in consumer choice
538 research. *Experimental Psychology*, 66, 68-76. doi: 10.1027/1618-3169/a000420
- 539 Klein, S. A., Hilbig, B. E., & Heck, D. W. (2017). Which is the greater good? A social
540 dilemma paradigm disentangling environmentalism and cooperation. *Journal of*
541 *Environmental Psychology*, 53, 40-49. doi: 10.1016/j.jenvp.2017.06.001
- 542 Lange, F. (2022). Behavioral paradigms for studying pro-environmental behavior: A
543 systematic review. *Behavior Research Methods*. doi: 10.3758/s13428-022-01825-4
- 544 Lange, F., & Dewitte, S. (2019). Measuring pro-environmental behavior: Review and
545 recommendations. *Journal of Environmental Psychology*, 63, 92-100. doi:
546 10.1016/j.jenvp.2019.04.009
- 547 Lange, F., & Dewitte, S. (2022). The Work for Environmental Protection Task: A
548 consequential web-based procedure for studying pro-environmental behavior.
549 *Behavior Research Methods*, 54, 133-145. doi: 10.3758/s13428-021-01617-2
- 550 Lange, F., & Dewitte, S. (2021). Test-retest reliability and construct validity of the Pro-
551 Environmental Behavior Task. *Journal of Environmental Psychology*, 73, 101550. doi:
552 10.1016/j.jenvp.2021.101550
- 553 Lange, F., Steinke, A., & Dewitte, S. (2018). The Pro-Environmental Behavior Task: A
554 laboratory measure of actual pro-environmental behavior. *Journal of Environmental*
555 *Psychology*, 56, 46-54. doi: 10.1016/j.jenvp.2018.02.007

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

- 556 Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature
557 contact, nature connectedness and associations with health, wellbeing and pro-
558 environmental behaviours. *Journal of Environmental Psychology*, 68, 101389. doi:
559 10.1016/j.jenvp.2020.101389
- 560 Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature
561 beneficial? The role of connectedness to nature. *Environment and Behavior*, 41(5),
562 607-643. doi: 10.1177/0013916508319745
- 563 McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on
564 positive and negative affect: A meta-analysis. *The Journal of Positive Psychology*,
565 10(6), 507-519. doi: 10.1080/17439760.2014.994224
- 566 McShane, B. B., Tackett, J. L., Böckenholt, U., & Gelman, A. (2019). Large-scale replication
567 projects in contemporary psychological research. *The American Statistician*, 73(sup1),
568 99-105. doi: 10.1080/00031305.2018.1505655
- 569 Meidenbauer, K. L., Stenfors, C. U., Bratman, G. N., Gross, J. J., Schertz, K. E., Choe, K. W.,
570 & Berman, M. G. (2020). The affective benefits of nature exposure: What's nature got
571 to do with it? *Journal of Environmental Psychology*, 72, 101498. doi:
572 10.1016/j.jenvp.2020.101498
- 573 Nord, M., Luloff, A. E., & Bridger, J. C. (1998). The association of forest recreation with
574 environmentalism. *Environment and Behavior*, 30, 235-246. doi:
575 10.1177/0013916598302006
- 576 Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the small
577 self, and prosocial behavior. *Journal of Personality and Social Psychology*, 108, 883-
578 899. doi: 10.1037/pspi0000018

NATURE EXPOSURE AND PRO-ENVIRONMENTAL BEHAVIOR

- 579 Schertz, K. E., & Berman, M. G. (2019). Understanding nature and its cognitive benefits.
580 *Current Directions in Psychological Science*, 28, 496-502. doi:
581 10.1177/0963721419854100
- 582 Soliman, M., Peetz, J., & Davydenko, M. (2017). The impact of immersive technology on
583 nature relatedness and pro-environmental behavior. *Journal of Media Psychology*, 29,
584 8-17. doi: 10.1027/1864-1105/a000213
- 585 Whitburn, J., Linklater, W. L., & Milfont, T. L. (2019). Exposure to urban nature and tree
586 planting are related to pro-environmental behavior via connection to nature, the use of
587 nature for psychological restoration, and environmental attitudes. *Environment and*
588 *Behavior*, 51, 787-810. doi: 10.1177/0013916517751009
- 589 Zelenski, J. M., Dopko, R. L., & Capaldi, C. A. (2015). Cooperation is in our nature: Nature
590 exposure may promote cooperative and environmentally sustainable behavior. *Journal*
591 *of Environmental Psychology*, 42, 24-31. doi: 10.1016/j.jenvp.2015.01.005A