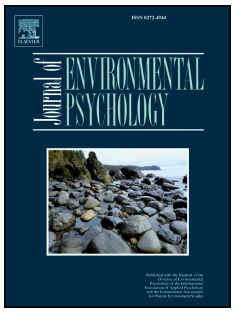

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Implicit Reminders of Reputation and Nature Reduce Littering more than Explicit Information on Injunctive Norms and Monetary Costs

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ABSTRACT

The present research addresses tools that could help reduce littering in society. Four interventions were tested which, based on different processes, should reduce littering: monetary information, the depicted injunctive norm, watching eyes and a nature picture. To test these interventions, a randomized controlled trial (RCT) involving 440 community building's waste disposal areas (N = 71,155) was conducted in Vienna. Littering was assessed before the intervention, 24 to 48 hours after, and again seven weeks after the intervention. Results show that the financial intervention (monetary information) hardly had any effect on littering whereas the norm-based intervention (depicted injunctive norm) led to more littering compared to the control and in particular, the nature picture. In contrast, the reputation-based intervention (watching eyes) and ecology-based intervention (nature picture) reduced littering over time by 4.7%. Thus, interventions based on implicit and soft appeals to reputation and ecology are more effective in fostering clean environments than classical interventions applying explicit information on finances and norms.

KEYWORDS:

Littering, intervention, behaviour change, field experiment, implicit processes, explicit processes

Introduction

Littered waste causes enormous environmental, and financial costs to societies. The reduction of littering and fostering of recycling are seen as important factors in fighting climate change (Wijkman & Skånberg, 2015). Not surprisingly, political stakeholders such as the European Union are implementing more stringent regulations (e.g., Waste Framework Directive), including penalties for institutions, to reduce littering. Likewise, a growing body of research examines various behavioural interventions aimed to reduce littering (e.g., Almosa, et al., 2017; Schultz et al., 2013). However, extant research on littering often examines single interventions with no control conditions, short-term effects, relatively small samples, with a particular focus on attitudes, beliefs, or intentions rather than actual littering behaviour (de Kort et al., 2008; Dur & Vollaard, 2019; Dwyer et al., 1993; Hansmann & Steimer, 2016). We address this gap by performing a large scale pre-registered randomized control trial (RCT) with a pre-post design to examine functionally different littering interventions in 440 waste disposal areas (71,155 inhabitants) of social housing buildings in Vienna over a period of seven weeks. Waste disposal areas are commonly designated indoor areas (i.e., rooms inside a building) or outdoor areas (i.e., metal "cages" outside a building) for waste disposal in the social housing buildings. In the following, we discuss the aim of this study, the context of the social housing buildings, and the different options to reduce littering before presenting the four interventions that were tested in the present study.

The aim of the current study was to reduce littering in the social housing buildings of Vienna. The city of Vienna is the biggest communal owner of apartments in Europe, allowing about 500.000 people, corresponding to 25% of the city population, to live in one of the 220.000 apartments (http://socialhousing.wien). Although also the middle-class lives in these apartments, inhabitants of social housing are, compared to the average population of Vienna, lower income. Thus, our study sought to test cost-effective interventions rather than

interventions that were too ambitious or simply not feasible. For example, costly interventions such as permanent cleaning (presence of existing litter leads to more litter, Schultz et al., 2013) and personal education (e.g., personnel demonstrating desired waste disposal behaviour, found to be effective by Sussman et al., 2013) were not feasible. Similarly, we suspended the idea of installing lemon scent-dispersers (reported to be effective by De Lange et al., 2012) as they would require regular costly maintenance work.

The most recent meta-analyses on littering (Almosa, et al., 2017) indicates that also cost-effective social marketing interventions – that is, interventions that use tools and techniques from marketing (e.g., communication through messages on posters) – are effective to reduce littering. However, the authors conclude that research on these "easy to implement" interventions has some limitations, as a theory-driven approach is often missing when these interventions are designed and tested (Almosa, et al., 2017; see also Dwyer et al., 1993). Thus, there is a need to evaluate different theory-guided interventions that are assummed to reduce littering.

Four interventions to reduce littering

The present study investigates four cheap poster-based anti-littering interventions, each of which captures relatively distinct psychological routes: monetary information, the depicted injunctive norm, watching eyes, and a nature picture. In the following we present each of these classical explicit but also rather novel implicit interventions in detail. The most classic intervention emphasizes incentives, often in the form of monetary rewards or punishment. In particular, past research has revealed that in various contexts, highlighting financial consequences of norm violations is an effective way to promote pro-environmental behaviour (Bolderdijk et al., 2013; Fujii, 2007; Steg & Vlek, 2009). However, such interventions are often more effective when extrinsic motivations to protect the environment are more dominant than intrinsic motivations (De Dominicis et al., 2017; Schwartz et al.,

2019) and when such consequences are not only hypothetical (Balliet et al., 2011). In a social housing context with a lower-income population the monetary consequences of a certain behaviour might be even more relevant than in other housing contexts. Beyond classic *incentive-based* interventions, literature provides at least three distinct interventions that go beyond monetary incentives: namely, norm-based interventions, reputation-based interventions, and ecology-based interventions.

An important category of behavioural change focuses on highlighting norms. A key example is to emphasize the "appropriate" behaviour (i.e., an injunctive norm) which has produced considerable research (Almosa et al., 2017; Cialdini et al., 1990, Geller et al., 1989, Reich & Robertson, 1979). The injunctive norm is distinct from the descriptive norm that states the "current" behaviour. While the injunctive norm may inspire behaviour change, the descriptive norm may backfire as it manifests current behavioural routines. Such *norm-based* cooperation can be elicited in various ways, including the use of explicit verbal prompts (Durdan et al., 1985; Geller et al., 1989), or visual depictions of role models (Geller et al., 1989). Norm-based cooperation is sometimes accompanied by providing social models (e.g., Sussman et al., 2013) which may trigger explicit or implicit forms of social learning (Bandura, 1971).

A third category of intervention involves the presence of watching eyes (Bateson et al., 2015) which, at least in less frequented locations, are assumed to elicit a feeling of being monitored and reputational concerns, which in turn increase norm-compliant behaviour (e.g., Ernest-Jones et al., 2011; Francey & Bergmüller, 2012; Manesi et al., 2016; Wu et al., 2016). Thus, this intervention captures *reputation-based* cooperation. Slightly different, it also might simulate a feeling of surveillance which than deters non-compliant behaviour. Watching eyes displayed on posters have been one of the most recently-implemented (and cost-effective) interventions to reduce various forms of norm vioations, including littering (Francey &

Bergmüller, 2012; Bateson et al., 2015), bicycle theft (Nettle et al.,2012) and not paying for drinks (Bateson et al., 2006).

A fourth more novel category of interventions focuses on environmental appeals (cf. Bolderdijk et al., 2013; Hansmann & Steimer, 2016). In particular, pictures of nature, such as landscapes, or sometimes specific features of nature (e.g., a panda), constitute another intervention which captures *ecology-based* cooperation (Van Lange, 2021; Zelenski et al., 2015). Ecology-based cooperation is likly based on the intrinsic motivation to protect the environment. Pictures of untouched natural landscapes may create positive emotions, connectedness to nature, a concern for the beauty of the ecosystem, or implicit worry about its conservation, which in turn triggers cooperation (see e.g., Zelenski et al., 2015; Zhang et al., 2014). For instance, posters displaying negative consequences of littered plastic-waste on animals were shown to reduce plastic waste (Luo, Douglas, Pahl, & Zhao, 2022).

The interventions presented are addressing four conceptually different psychological routes (incentives, norms, reputation, ecology) and in addition, can be categorized into whether they explicitly or implicitly encourage the desired behaviour. Whereas the classical interventions, the incentives and norms explicitly state to keep the waste disposal areas clean the other interventions, the watching eyes and the nature picture, are rather implicit, as they do not mention littering at all.

Explicitly addressing the problem of littering, aiming at logical insight and knowledge, is the most frequently applied anti-littering intervention (Almosa et al., 2017; Desa et al., 2011; Dwyer et al., 1993). Next to financial consequences and the use of norms, further prominent interventions involve education (Desa et al.,2011; Geller, et al., 1977) or prohibition (Keizer et al., 2011). In contrast, implicit attempts to change littering behaviour without a direct promotion of correct waste disposal behaviour are a rather new approach (de Kort et al., 2008; Kolodko & Read, 2018). Next to the watching eyes and nature picture,

other interventions include creatively designed trash cans (de Kort et al., 2008; Gerlach, van der Meer et al., 2018) or green footprints leading to a trash can (Keep Britain Tidy, 2015).

The aim of this paper is to examine the relative effectiveness of four interventions in promoting peoples' compliance to keep waste disposal areas clean. This overall aim includes our goal to explore whether one or more of these interventions are effective at all in promoting compliance. In the following we present the methods of our RCT to answer these research questions.

Methods

Sample

Assuming small to medium effects, we planned to have about 90 waste disposal areas per experimental condition.[1] Thus, expecting a loss in sample size, the initial sample consisted of 500 waste disposal areas. Indeed 60 waste disposal areas were excluded because they were not suitable (they had no walls), had been misclassified (e.g., laundry facilities) or were not found (existed in the records only). The final sample consisted of 440 waste disposal areas in 89 social housing buildings in 15 (out of 23) different districts of Vienna, covering 29,935 apartments with approximately 71,155 inhabitants (population per building: *min.* 46; *max.* 6677; *median* = 1,012). Sample size per experimental condition: control: 89; monetary information: 90; depicted injunctive norm: 87; watching eyes: 87; nature picture: 87. Of the total sample, 264 disposal areas were indoors, and 176 disposal areas were outdoors. All waste disposal areas contained paper and residual waste containers which were cleaned and visited by municipal waste collection teams at different days and frequencies a week.

[1] A power analyses with G*power for a t-test with two dependent means (power: 95%, $p = .05$, $d = .35$, two-sided) reveled a necessary sample size of 90 per condition.

Materials

Pre-study: Manipulation check

An online pre-test (N = 356 Viennese, M_{age} = 41.57, SD = 15.73) was conducted to do a manipulation check of the interventions (within-subject design). After being primed to the situation of entering a waste disposal area, participants were presented preliminary interventions in random order, see Supplementary Figure 1 for the details. Then, participants were asked to answer the question "Would you dispose your trash bag into the waste container?" on a 10-point Likert-type scale with labelled endpoints (1 = very unlikely; 10 = very likely). After that, different statements referring to the intervention mechanisms were presented, and participants indicated their agreement on a Likert-type scale with labelled endpoints (1 = strongly disagree, 10 = strongly agree).

Pre-study results showed that participants generally indicated high compliance when disposing of their waste (M= 8.96, SD = 2.24), indicating that there might have been a difference between their self-perception and their actual behaviour (Goldstein & Cialdini, 2007). Results from an repeated measures ANOVA and post-hoc paired t-tests also showed that the monetary information (M = 5.46, SD = 3.67) led to a significantly greater agreement with the statement "I want to save money" than the other posters (repeated measures ANOVA: F(3, 1065) = 41.58, p > . 001, η^2 = .105; post-hoc paired t-tests: watching eyes: M = 4.24, SD = 3.45, t(355) = 7.55, p < .001, 95%CI: 0.292, 0.508; nature picture: M = 4.04, SD = 3.34, t(355) = 8.62, p < .001, 95%CI: 0.347, 0.566; depicted injunctive norm: M = 4.38; SD = 3.51, t(355) = 6.92, p < .001; 95%CI: 0.259, 0.474). For the depicted injunctive norm (M = 7.18, SD = 3.15), a repeated measures ANOVA showed marginal non-significant difference to the other posters (F(3, 1065) = 3.05, p = . 082, η^2 = .009) concerning the agreement with the statement "It is expected of me to behave like this". However, post-hoc paired t-tests showed an expected significant difference compared to the nature pictures (M = 6.82, SD =

3.30, $t(355) = 2.77$, p = .006, 95%CI: 0.042, 0.251) and the monetary information ($M = 6.92$, $SD = 3.16$, $t(355) = 2.20$, $p = .028$, 95%CI: 0.012, 0.221) and marginally non-significant difference compared to the watching eyes ($M = 6.97$, SD = 3.11, $t(355) = 1.79$, $p = .075$, 95%CI: -0.009, 0.199). The watching eyes ($M = 4.95$, $SD = 3.68$) led to a significantly greater agreement with the statement "I feel watched" than the other posters (repeated measures ANOVA: (3, 1065) = 93,43, $p < .001$, $\eta^2 = .208$; post-hoc paired t-tests: nature picture: $M = 2.53$, $SD = 2.65$), $t(355) = 12.1$, $p < .001$, 95%CI: 0.527, 0.755; monetary information: $M = 2.80$, $SD = 2.89$, $t(355) = 11.35$, $p < .001$, 95%CI: 0.488, 0.714; depicted injunctive norm: $M = 2.97$, $SD = 2.97$, $t(355) = 10.35$, $p < .001$, 95%CI: 0.437, 0.660). The nature picture ($M = 8.89$, $SD = 2.28$) led to a greater agreement with the statement "I respect nature" than the other posters ($F(3, 1065) = 6.87$, $p = .009$, $\eta^2 = .019$; post-hoc paired t-tests: eyes poster: $M = 8.51$, $SD = 2.60$, $t(355) = 3.95$, $p < .001$, 95%CI: 0.104, 0.314; monetary information ($M = 8.76$, $SD = 2.37$, $t(355) = 1.57$, $p = .058$, 95%CI: -0.021, 0.187; depicted injunctive norm ($M = 8.82$, $SD = 2.27$, $t(355) = 1.01$, $p = .156$, 95%CI: -0.050, 0.158).

Manipulation of interventions

The posters displaying the interventions are shown in Figure 1. All posters were prepared by graphic designers who ensured that the appearance was aligned with the corporate design of the city of Vienna. For the monetary information, a gain, rather than loss frame, was chosen as costs could provoke backlash (cf. Reich & Robertson, 1979) as such extra costs are never earmarked in utility bills and could be understood as future cost increase, while a monetary gain is easily understood. The potential gain was calculated assuming an average flat size of 60 m2, using the largest difference in utility costs between two social housing buildings; data for more granular feedback were not available. For the depicted injunctive norm, colourful illustrations specifying desirable behaviour (left) and

negative consequences of undesirable behaviour (right) (cf. Geller et al., 1989) without wordy explanations were used. The intervention consisted of two half-sized posters, one focusing on waste and one on paper trash. For the watching eyes, we followed the literature by ensuring a direct, open and serious expression by a male pair of eyes (Bateson et al., 2015). The nature picture displayed the conservation area Danube meadow at the borders of the city of Vienna, ensuring natural bright colours, presence of water and sky without the sign of human intervention (cf. Vining, Merrick, & Price,2008; Zhang et al., 2014).

The posters had the size of A1 (594mm x 841mm). The poster conditions and control condition were randomly assigned to one of the 440 waste disposal areas – leading to an even distribution of conditions among indoor and outdoor waste disposal areas (χ^2 (4, N = 440) = 1.59, p =.81). Conditions did not differ concerning the days at which waste was collected (X^2 (4, N = 440) = .70, p =.951). In the control condition, no intervention was introduced, that is, no poster was attached to the wall.

[Insert Figure 1 here]

Assessment of floor cleanness

Floor cleanness was assessed with pictures taken from the floor of a waste disposal area. This procedure was based on Bator et al. (2011), where research assistants take pictures of a location and subsequently rate the amount of litter on a scale of 0 (not at all littered) to 10 (extremely littered). Overall, six pictures were taken per waste disposal area over three assessment times: two before the intervention to assess the baseline cleanness (T1), two about 24 to 48 hours after the intervention to assess the short-term effect (T2) and two about seven weeks after the intervention to assess the mid-term effect (T3). Figure 2 visualizes the temporal unfolding of the experiment.

[Insert Figure 2 here]

The timing for a picture per waste disposal area over the different assessment times was kept constant; pictures were taken between Tuesday and Thursday in the morning or in the afternoon. Pictures were taken by about 30 employees of the social housing company whose regular job is to control the waste disposal areas and who were trained to be research assistants. They were instructed to take a picture which shows the whole floor (or the characteristic part of the floor) and an identifier sign with the waste disposal area number. To allow a blind assessment of the pictures, each picture only showed the floor but not the walls with the interventions.

Each picture was assessed on a 7-point Likert type scale ranging from 1 = totally clean (not a single item is on the floor), 2 = very clean (one item is on the floor), 3 = clean (two items are on the floor), 4 = relatively dirty (three items are on the floor), 5 = dirty (many items are on the floor), 6 = very dirty (many small and large items are on the floor), 7 = totally dirty (extremely messy). Assessment was conducted by two trained research assistants who reached a moderate agreement (interrater reliability: Kappa for the six measurements: .48, 56, .43, .53, .41, .39). The final value for floor cleanness was the mean of all ratings at one assessment time.

Assessment of control variables

At each of the six assessment points, research assistants assessed several control variables. A detailed description of these variables as well as their correlation with floor cleanness can be found in Supplementary Table 1.

Procedure

The field experiment received ethical approval from the Institute for Advanced Studies' ethics commission and was pre-registered (https://www.socialscienceregistry.org/trials/6108). While the preregistration suggests linear regressions as a method, we employ repeated measures ANOVAs since the sample is constant across the measurement times. As preregistered, all observations from the sample that were "sparkling clean" at baseline (floor cleanness = 1) were excluded leading to N = 359 (control: 75; monetary information: 71; depicted injuctive norm: 71; watching eyes: 72; nature picture: 70)[2]. All analyses with the full sample as a robustness check are presented in the supplementary information and show qualitatively the same results. The data collection was conducted between June 30th, 2020 and September 3rd, 2020 during the COVID-19 pandemic. After the first assessment of baseline cleanness, posters were assembled within three days. After the second assessment of cleanness, 39 missing posters (most likely because they fell off the wall) were replaced within a week. We did not remove or replace posters after the third assessment.

Analytical strategy

To answer our first preregistered research question, whether our interventions increase peoples' compliance to keep waste disposal areas clean, we conducted four separate steps of repeated measures analyses. In the first step, we analysed whether there is an overall difference in floor cleanness between conditions over time. For this, a repeated measures ANOVA with five conditions (four experimental conditions and the control condition) as independent variable, floor cleanness at the three assessment times as the repeated measures factor and area location (indoor, outdoor) as control variable were conducted. This

[2] In waste disposal areas with sparkling clean floors (floor cleanness = 1), by definition, no improvement is possible. Thus, we preregistered to focus on waste disposal areas which fulfil the prerequisite of a dirty floor in order, to observe a possible improvement due to our interventions over time.

corresponds to a 5 (condition) x 3 (time) mixed design ANOVA with one control variable (location). In the results section we present, for this and all other analyses, results without the control variable that show qualitatively identical outcomes in footnotes. In the second step, the found interaction effects were disaggregated. It was analysed which experimental condition (four interventions) differs from the control condition in floor cleanness over time (again controlling for location). For this, four separate repeated measures ANOVAs with each intervention versus the control condition as independent variable, floor cleanness at the three assessment times as the repeated measures factor and location as control variable were conducted.

The third and fourth step aimed to examine possible differences between intervention and control conditions in floor cleanness over time in detail based on difference values. The difference values were calculated by subtracting floor cleanness at T2 from floor cleanness at T1 to show the de- or increase in floor cleanness on the short-term and by subtracting floor cleanness at T3 from floor cleanness at T1 to show the de- or increase in floor cleanness on the long-term. Thus, in the third step, it was analysed whether a difference between intervention and control condition found in Step 2 is rather a short and/or long-term effect. For this, separate ANOVAs with the intervention versus the control condition as independent variable and the differences values for the short-term and long-term effect were conducted, again with location as control variable. In the fourth step, it was analysed whether there is a change in floor-cleanness within a condition over time (within-location effect) and thus, also the magnitude of a possible change was examined. For this, separated paired-t-tests were conducted for the short-term and longer-term effect.

To answer our second preregistered research question about which intervention is the most effective, we build on the repeated measures ANOVA conducted for research question 1. In addition, we also examined obvious differences visible in the graphical illustration of

the data. Based on that, we analysed differences in floor cleanness over time between the interventions based on two steps. Thus, as fifth step, six separate repeated measures ANOVAs with e.g., intervention A versus intervention B as independent variable, floor cleanness at the three assessment times as the repeated measures factor and location as control variable were conducted. In the sixth step, one repeated measures ANOVA with explicit (monetary information, depicted injuctive norm) versus implicit (watching eyes, nature picture) interventions as independent variable and floor cleanness at the three assessment times as repeated measurement factor and area location as control were conducted. This corresponds to a 2 (explicit, implicit) x 3 (time) mixed design ANOVA with one control variable. In the seventh step, it was analysed whether there is a change in floor-cleanness within a condition over time (within-location effect) and thus, also the magnitude of a possible change was examined. For this, separated paired-t-tests were conducted for the short-term and longer-term effect. In the following we present the results in detail. A summary can be found in Table 1.

Results

Step 1: Overall changes in cleanness of conditions over time

Following step 1 of our analytical strategy, a 5 (conditions) x 3 (assessment times) repeated measurement ANOVA with area location as control variable was conducted. Results showed a marginal non-significant main effect of the experimental conditions ($F(4, 353) = 2.09$, $p = .081$, $\eta^2 = .023$), no effect for the repeated measures factor ($F(2, 706) = 0.84$, $p = .434$, $\eta^2 = .002$), and did show the expected significant interaction between experimental conditions and assessment time ($F(8,706) = 1.96$, $p = .048$, $\eta^2 = .022$)[3]. The significant effect of the area control variable ($F(1, 353) = 14.42$, $p < .001$; $\eta^2 = .039$; 95% CI: 0.154, 0.508))

[3] Interaction effect without control variable: ($F(8,708) = 1.94$, $p = .052$, $\eta^2 = .021$).

showed that outdoor areas (T1: M = 2.20, SD = 0.91; T2: M = 2.03, SD = 0.97; T3: M = 2.14, SD = 1.06) are cleaner than indoor areas (T1: M = 2.48, SD = 1.12; T2: M = 2.47, SD = 1.22; T3: M = 2.41, SD = 1.05).

Step 2: Changes in cleanness over time between interventions and control condition

Following step 2 of our analytical strategy, we conducted four separate 2 (intervention, control) x 3 (assessment times) repeated measurement ANOVAs with area location as control. Concerning the monetary information, results showed that there was no difference between the monetary information and the control condition over time (interaction between condition and assessment time: $F(2, 286) = 1.30$, $p = .273$, $\eta^2 = .009$). Concerning the depicted injuctive norm, results also showed no difference between the norm and control condition over time (interaction between condition and assessment time: $F(2, 286) = 1.09$, $p = .337$, $\eta^2 = .008$). However, based on graphical differences in Figure 3 at T3, a between location t-test showed that the depicted injunctive norm (M = 2.62; SD = 1.18) lead to significantly dirtier floors than the control condition at T3 (M = 2.14; SD = 1.00; $t(144) = 2.65$; $p = .009$; d = 0.44; 95% CI: 0.122, 0.838). On a 7-point scale, at time 3 the norm pictures had a 6.8% dirtier floor than the control condition. Results concerning watching eyes also showed no difference between the eyes and control condition over time (interaction between condition and assessment time: $F(2, 288) = 2.31$, $p = .101$, $\eta^2 = .016$)[4]. Results concerning the nature picture showed a marginal non-significant reduction of littering over time (interaction between condition and assessment time: $F(2, 284) = 2.82$, $p = .061$, $\eta^2 = .019$)[5].

[4] Without control variable: $F(2, 290) = 2.31$, $p = .101$, $\eta^2 = .016$).
[5] Without control variable: $F(2, 286) = 2.81$, $p = .061$, $\eta^2 = .019$).

Step 3: Short-term and long-term differences in cleanness between interventions and control condition

Following step 3 of our analytical strategy, we conducted separate 2 (intervention, control) x 1 (difference value) ANOVAs with location as control variable for the two relevant conditions, watching eyes and nature picture. Concerning the watching eyes, results showed a marginal non-significant difference between the eyes and the control condition between T1 versus T2 (watching eyes: M = -0.17, SD = 1.16; control: M = 0.15, SD = 1.15; $F(1,147)$ = 2.96; p = .087; η^2 = .020; 95%CI:-0.707, 0.049) and a significant difference for T1 versus T3 (watching eyes: M = -0.33, SD = 1.03; control: M = 0.05, SD = 1.09; $F(1,147)$ = 4.60; p = .034; η^2 = .031; 95%CI:-0.724, -0.030). Concerning the nature picture, results showed a significant difference between nature picture and control condition between T1 versus T2 (nature picture: M = -0.29, SD = 1.28; control: M = 0.15, SD = 1.15; $F(1,145)$ = 4.76, p = .031; η^2 = .032; 95%CI:-0.837, -0.041) and a marginal non-significant difference for T1 versus T3 (nature picture: M = -0.33, SD = 1.24; control: M = 0.05, SD = 1.09; $F(1,145)$ = 3.85; p = .051; η^2 = .026; 95%CI:-0.761, 0.003).

Step 4: Short-term and longer-term changes in cleanness of the watching eyes and nature pictures

Following step 4 of our analytical strategy, we conducted three separate paired-t-tests for the watching eyes, the nature picture, and the control condition. Concerning the watching eyes, results showed no significant change between T1 and T2 ($t(71)$ = 1.27, p =.210, d = .15; 95% CI: -0.084, 0.381) and a significant increase of cleanness between T1 and T3 ($t(71)$ = 2.71, p =.008, d = .32; 95% CI: 0.081, 0.555). Thus, on a 7-point scale, the longer-term improvement (M= -0.33) from the watching eyes is 4.7%.

Concerning the nature picture, results showed a marginal non-significant result in cleanness between T1 and T2 ($t(69) = 1.87$, $p = .066$, $d = .22$; 95% CI: -0.015, 0.460) and a significant increase in cleanness between T1 and T3 ($t(69) = 2.24$, $p = .029$, $d = .27$; 95% CI: 0.028, 0.505). On a 7-point scale, the short-term improvement ($M = -0.29$) of the nature picture is 4.1% and the longer-term improvement ($M = -0.33$) is 4.7%.

Moreover, results showed that there is no significant change of cleanness in the control condition between T1 and T2 ($t(74) = -1.15$, $p = .253$, $d = -0.13$; 95% CI: -0.360, 0.095) or T1 and T3 ($t(74) = 2.71$, $p = .711$, $d = -0.04$; 95% CI: -0.269, 0.184).

Step 5: Different changes of cleanness between interventions

Following step 5 of our analytical strategy, we conducted six separate 2 (intervention A, intervention B) x 3 (assessment time) repeated measures ANOVAs with location as control variable. Results showed a significant difference between the watching eyes and the depicted injunctive norm (interaction between condition and assessment time: $F(2, 280) = 3.55$, $p = .030$, $\eta^2 = .025$)[6] indicating as Figure 3 shows that the watching eyes compared to the injunctive norm lead to an increase of floor cleanness. Results also showed a significant difference between the nature pictures and the depicted injunctive norm (interaction between condition and assessment time: $F(2, 276) = 3.17$, $p = .043$, $\eta^2 = .022$)[7] indicating that the nature pictures compared to the depicted injunctive norm lead to an increase of floor cleanness. A marginal non-significant difference was found between watching eyes and the injunctive norm ($F(2, 280) = 2.71$, $p = .068$, $\eta^2 = .019$)[8] and no difference was found between watching eyes and the monetary information or the nature picture and the monetary information ($p = .138$).

[6] Without control variable: $F(2, 282) = 3.54$, $p = .031$, $\eta^2 = .025$)
[7] Without control variable: $F(2, 278) = 3.17$, $p = .044$, $\eta^2 = .022$)
[8] Without control variable: $F(2, 282) = 2.65$, $p = .073$, $\eta^2 = .018$).

[Insert Figure 3 here]

Step 6: Differences between explicit and implicit interventions

Following step 6 of our analytical strategy, we conducted 2 (explicit interventions, implicit interventions) x 3 (assessment time) repeated measures ANOVAs with location as control variable. Results showed no main effect of explicit versus implicit interventions (F(1, 281) = 0.23, p = .630, η^2 = .001) and no main effect of the repeated measures factor (F(2, 562) = 0.89, p = .410, η^2 = .003). However, the expected significant interaction effect between explicit/implicit and repeated measures factor (F(2, 562) = 5.82, p = .003, η^2 = .020)[9] showed that implicit interventions compared to explicit interventions lead to an improvement of cleanness over time. As Figure 3 shows, explicit interventions increase whereas implicit interventions decrease littering over time. The significant main effect of the control variable area location (F(1, 281) = 11.37, p = .001, η^2 = .039; 95%CI: 0.144, 0.553) showed again that outdoor areas are cleaner than indoor areas.

Step 7: Short-term and long-term changes in cleanness of explicit and implicit interventions

Following step 7 of our analytical strategy, we conducted two separate paired-t-tests for the explicit and implicit interventions (Figure 4). Concerning the explicit interventions, results showed no significant change between T1 and T2 (t(141) = 0.27, p =.785, d = .02; 95% CI: -0.142, 0.187) and no significant change between T1 and T3 (t(141) = -1.40, p =.162, d = .12; 95% CI: -0.283, 0.047).

[9] Without control variable: (F(2, 562) = 5.64, p = .004, η^2 = .020)

Concerning the implicit interventions, results showed a significant change between T1 and T2 ($t(141) = 2.24$, $p = .027$, $d = .18$; 95% CI: 0.021, 0.353) and a significant increase of cleanness between T1 and T3 ($t(141) = 3.45$, $p = .001$, $d = .29$; 95% CI: 0.123, 0.458). On a 7-point scale, the short-term improvement ($M = -0.23$) of the implicit interventions is 3.27% and the longer-term improvement ($M = -0.33$) is 4.7%.

[Insert Figure 4 here]

[Insert Table 1 here]

Discussion

Littering is a visible environmental-harming behaviour (Huffman et al., 1995). In the present large-scale RCT, four interventions were derived from the literature and tested. As an initial and comprehensive test of four interventions that could be used in real-life settings of social housing, we examined interventions that differ in terms of the primary mechanism that is activated (incentive, norm, ecology, or reputation) along with the explicit versus implicit presentation mode. The classical interventions, the monetary information and the depicted injunctive norm, explicitly address littering based on incentivization and norm-based concerns related to logical and normative insight. The rather novel interventions, the watching eyes and the nature pictures, use attentional cues to elicit reputational and ecology-based concerns and only implicitly address littering.

Results show that the four interventions did differ in terms of effectiveness over time. Highlighting financial consequences of behaviour is a standard measure to promote rule compliance (Balliet et al., 2011). However, the present results extend previous research by showing that incentive-based motivations hardly work in the environmental realm (Bolderdijk et al., 2013), not even in a setting where individuals have a rather low income on average, such as in the present social housing buildings. An explanation might be, that

incentive-based approaches are unlikely to be effective when the risk of penalty is perceived as very low which is likely the case in the present situation. Another explanation could be that tenants disposing of their waste might not be able to read the information as it is often the children who bring the waste downstairs or that inhabitants do not read German well.

The norm-based intervention dating back to the research of Cialdini et al., (1990) and earlier studies (Reich & Robertson, 1979) led to 6.8% more littering than the control condition at time 3. Although, no significant result for a difference between all assessment times between the norm and control condition was found, the difference at time 3 indicates a backfiring effect. A previous RCT suggests that this might be the consequence of people perceiving that the injunctive norm (e.g., a prohibition sign on littering) is in stark contrast to the descriptive norm (e.g., observed littering; Keizer, Lindenberg, & Steg, 2011). Another reason might be that most people believe that they themselves do not litter and are morally superior to other people (e.g., Allison et al., 1988; Van Lange & Sedikides, 1998). Hence, they might feel that educational anti-littering interventions, such as the communication of the injunctive norm, are not relevant to them or worse, an insult, which may cause reactance (e.g., Brehm, 1966). Finally, albeit former research highlighted the importance of communicating negative consequences of non-compliance (cf. Geller et al., 1989), displaying over-full and dirty waste containers with rats might have backfired, possibly by inducing disgust and an urge to leave the areas fast.

In contrast, the reputation-based watching eyes lead to a small improvement of 4.7% of cleanliness over time. Although this improvement was again not significant compared to the development in the control condition, it was significant in the within-location paired-tests. The present setting of waste areas in which most people spend their time alone, might have been an important factor supporting the effect of the watching eyes, which substitute being

watched by others (Bateson et al., 2015)[10]. Also the finding that outdoor waste disposal areas are cleaner where others can observe behaviour more easily than in indoor areas indicates that reputation-based cooperation might be an important factor for environmental cooperation.

The nature picture decreased littering over time by 4.7%. This improvement was marginally non-significant compared to the development of the control group and significant in the within-location paired-tests. Thus, the present research extends previous field experiments by showing that not only exposure to real nature (Zelenski et al., 2015) or animal pictures (Wang et al. 2017) but also to pictures of untouched nature elicit behaviour-relevant ecology-based motivations (concerning nature's beauty, nature connectedness or people's "green" self-concept). This finding also confirms previous field experiments which suggest that an appeal to ecology-based motivations might be a more effective way to increase pro-environmental behaviour than injunctive norm-related prohibitions (Hansmann & Steimer, 2016).

To summarize, the data on all four interventions show that the picture displaying nature appeared most effective in reducing litter followed by a picture displaying watching eyes. However, both effects are rather small in magnitude. Finally, there are relatively clear statistical indications that the injunctive norm and the financial information have no large positive effects on cleanness. In contrast, there are weak (and marginally non-significant and non-significant) statistical trends that the injunctive norms might even have a backfiring effect. Results also show that the watching eyes and nature picture (both implicit) are superior compared to the depicted injunctive norm and partly also compared to the monetary information (both explicit). This outcome fuels the conclusion that some recent approaches to

[10] Although the watching eyes seem to be effective in rather isolated places, we recommend to use the watching eyes intervention with caution. As we interviewed a non-representative subsample of residents for a follow up study after our field experiment, a child reported that he was initially scared by the watching eyes.

implicit interventions (such as highlighting ecology or reputation) might be more effective than the more classic ones which focus on explicit information on incentives and norms. It is, therefore, possible that indirect and "soft appeals" might be more effective to reduce littering than direct attempts. One reason may be that subtle, indirect approaches match with the act of littering itself, an act which often may be the result of little deliberation. In contrast, direct informational or educational attempts might not concern or even provoke people (who think they themselves do not litter) or might be demotivating if contrasted by a descriptive norm of littering (Keizer et al., 2011).

Overall, it is noteworthy that the detrimental effects of the depicted injunctive norm, just like the positive effects of the watching eyes and nature picture, persisted or even became stronger over a period of seven weeks. Thus, effects of novel implicit interventions are not just short-term but extend into the future.

Findings also uncovered that outdoor waste disposal areas are generally cleaner than indoor areas. Why may that be? One interpretation is that outside locations are generally more attractive (i.e., more beautiful, brighter, better smelling) than indoor areas, so that people might spend more time at those locations and are more mindful of their waste disposal. Another explanation is that they allow observation by other people, so that reputation-based cooperation is more likely be activated in outside than indoor locations.

Some limitations have to be considered. The current results show pre-post effects and differences between interventions, but only partly effects of the interventions compared to the control condition. In addition, the effects found were small in magnitude often bordering rather than passing the criteria for statistical significance, despite the well-powered research design. One reason might be that overall, the waste disposal areas were (in contrast to expectations) rather clean such that the interventions did not have much potential to improve cleanness compared to the "clean" control condition. On a seven-point scale (1 = totally

clean, 7 = totally dirty) the mean cleanness at time 1 was 2.12 (*SD* = 1.09). In conclusion, the current results on the effects of the present interventions are most valid for places that a rather clean. The present data collection was conducted during the week, however, most waste might be disposed of during the weekends. Thus, future research should focus on a sample or data collection period (i.e., during weekends) with a higher potential to improve cleanness.

Moreover, the interrater reliability on the floor cleanness ratings was low to moderate (Kappa ranging from .39 to .56) which indicates that the reliability of our measurement was not perfect. However, although raters might not always have come up with the same absolute evaluation, a correlation of at least $r = .84$ indicates, that the raters agreed on their relative evaluation. Also, the approach to measure and rate twice for each assessment time should have increased stability of assessment. Nonetheless, these low levels of interrater reliability may have caused an underestimation of the effect size of the tested interventions. To increase interrater reliability, future studies should include multiple outcome measures (e.g., on small versus large objects, on disgust) to calibrate raters better for the most important outcome of overall cleanness. In addition, instead of one picture of the floor, several pictures could be taken to give raters a better impression of the situation in the waste disposal area.

Another limitation is, that the current study only observed the effects of the intervention over the period of seven weeks. Although this is one of the longest observations reported the literature, future research could study an even more extended time horizon to further explore the potential and limits of the four interventions on the long term. Another limitation is that the categorization into explicit and implicit interventions differ with respect to their content, and could even be interpreted along the lines of System 1 versus System 2 information processing (e.g., Evans, 2008; Kahneman, 2011). Hence, future research could make an even more clear-cut distinction between explicit and implicit interventions by using the same content but varying its communication (e.g., explicit nature information: “Keeping

the waste disposal areas keeps the environment clean" and implicit nature picture). A limitation of the present study is also that little is known about the underlying processes. For example, it is not clear whether the nature picture improves cleanness because it elicits a connectedness to nature or simply, because it leads to a more beautiful waste disposal area that people want to keep clean. Thus, future research also should address possible theoretical confounds in the interventions by including questionnaire data or by implementing interventions that are able to disentangle different psychological routes. We also recommend research that uses descriptive norms as a more indirect way in which to share normative information that is bound to elicit less psychological reactance.

We close by noting that our research provides early evidence of the effectiveness of four distinct interventions aimed at reducing people's actual littering behaviour. The interventions are derived from a substantial literature that largely has focused on single interventions and attitudes, beliefs and intentions in more controlled but less natural contexts. Our findings highlight the detrimental effects of injunctive norms in real-life contexts in which people develop habits and often may engage in behaviours with little or no thought or deliberation. The present findings also suggest that ecology- and reputation-based interventions, even conveyed on posters, may be effective. And given that the costs of posters are often low, such interventions are likely to be cost-effective. We look forward to research that replicates and extends these set of findings.

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Table 1: Summary of results

Analytical strategy		Statistical significance
RQ1: Do the interventions increase cleanness?		
Step 1	Overall changes: interaction effect of the 5 (conditions) x 3 (assessment times) repeated measurement ANOVA	$p = .048$
Step 2	Monetary information: interaction effect of the 2 (monetary information, control) x 3 (assessment times) repeated measurement ANOVA	$p = .273$
	Depicted injunctive norm: interaction effect of the 2 (depicted injuctive norm, control) x 3 (assessment times) repeated measurement ANOVA	$p = .337$
	Depicted injunctive norm versus control condition at T3	$p = .009$
	Watching eyes: interaction effect of the 2 (watching eyes, control) x 3 (assessment times) repeated measurement ANOVA	$p = .101$
	Nature picture: interaction effect of the 2 (depicted injunctive norm, control) x 3 (assessment times) repeated measurement ANOVA	$p = .061$
Step 3	Watching eyes: mean difference between watching eyes and the control condition on the short-term (ANOVA)	$p = .087$
	Watching eyes: mean difference between watching eyes and the control condition on the longer-term (ANOVA)	$p = .034$
	Nature picture: mean difference between nature picture and the control condition on the short-term (ANOVA)	$p = .031$
	Nature picture: Mean difference between nature picture and the control condition on the short-term (ANOVA)	$p = .051$
Step 4	Watching eyes: Whitin-condition short-term effect (paired-t-test)	$p = .210$
	Watching eyes: Whitin-condition longer-term effect (paired-t-test)	$p = .008$
	Nature picture: Whitin-condition short-term effect (paired-t-test)	$p = .066$
	Nature picture: Whitin-condition longer-term effect (paired-t-test)	$p = .029$
	Control condition: Whitin-condition short-term effect (paired-t-test)	$p = .253$
	Control condition: Whitin-condition longer-term effect (paired-t-test)	$p = .711$
RQ2: Which intervention is the most effective?		
Step 5	Difference between watching eyes and depicted injunctive norm: interaction effect of a 2 (watching eyes, depicted injunctive norm) x 3 (assessment times) repeated measurement ANOVA	$p = .030$
	Difference between nature pictures and depicted injunctive norm: interaction effect of a 2 (nature picture, depicted injunctive norm) x 3 (assessment times) repeated measurement ANOVA	$p = .043$
	Difference between watching eyes and monetary information: interaction effect of a 2 (watching eyes, monetary information) x 3 (assessment times) repeated measurement ANOVA	$p = .068$
	Difference between nature picture and monetary information: interaction effect of a 2 (nature picture, monetary information) x 3 (assessment times) repeated measurement ANOVA	$p = .138$
Step 6	Difference between explicit and implicit interventions: interaction effect of a 2 (explicit, implicit) x 3 (assessment times) repeated measurement ANOVA	$p = .003$
Step 7	Explicit intervention: Whitin-condition short-term effect (paired-t-test)	$p = .785$
	Explicit intervention: Whitin-condition longer-term effect (paired-t-test)	$p = .162$
	Implicit intervention: Whitin-condition short-term effect (paired-t-test)	$p = .027$

	Implicit intervention: Whitin-condition longer-term effect (paired-t-test)	$p = .001$

Figures

Figure 1

Manipulation of the four interventions

<table>
<tr><td rowspan="2">System 2</td><td>Monetary Information:
“A clean waste disposal area brings you up to 170€ per year.”</td><td>Depiction of the Injunctive Norm:
Visual explanation of the injunctive norm and the negative consequences</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td rowspan="2">System 1</td><td>Watching Eyes:</td><td>Nature Picture:</td></tr>
<tr><td> 
</td><td> 
</td></tr>
</table>

Figure 2

Flowchart of the experimental process

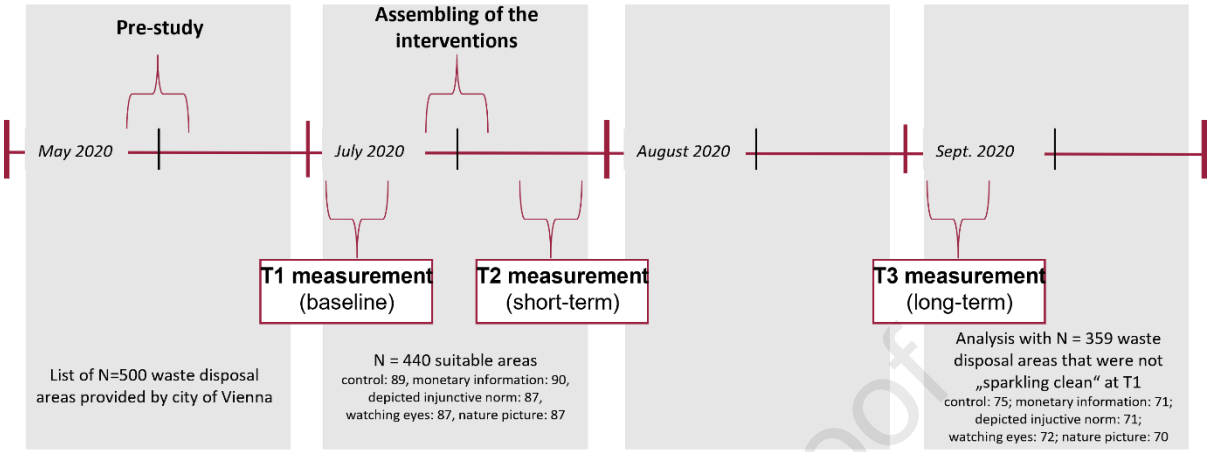
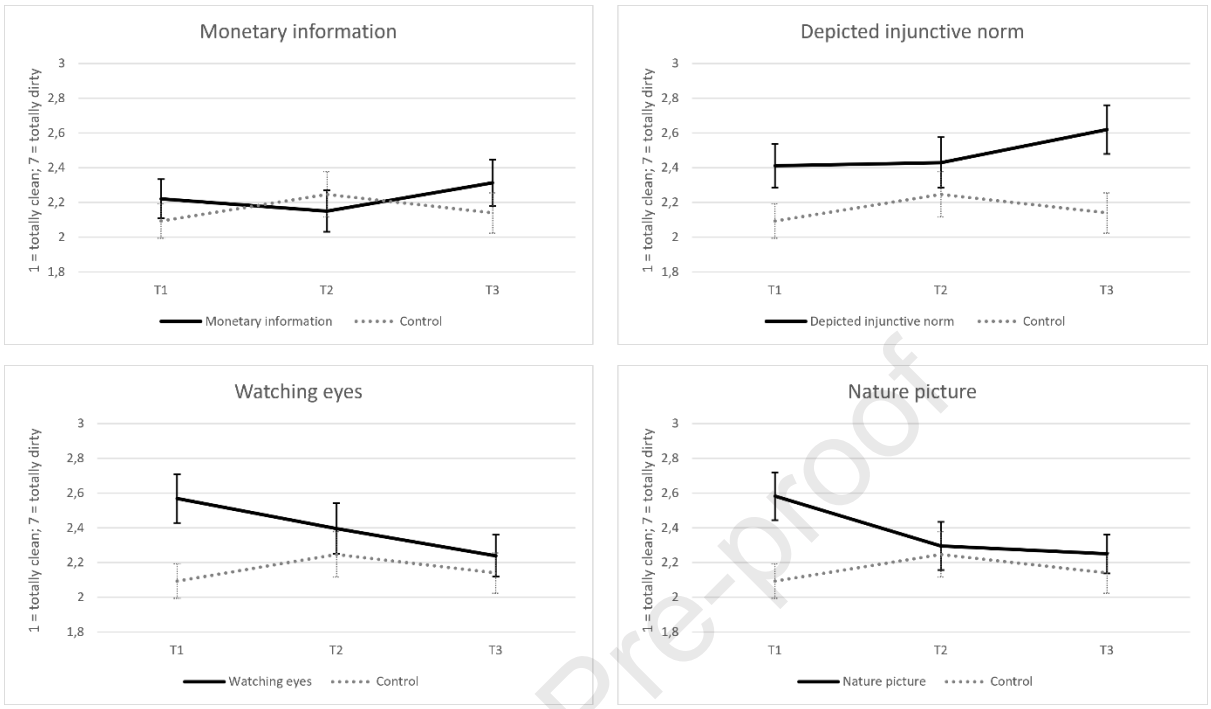


Figure 3

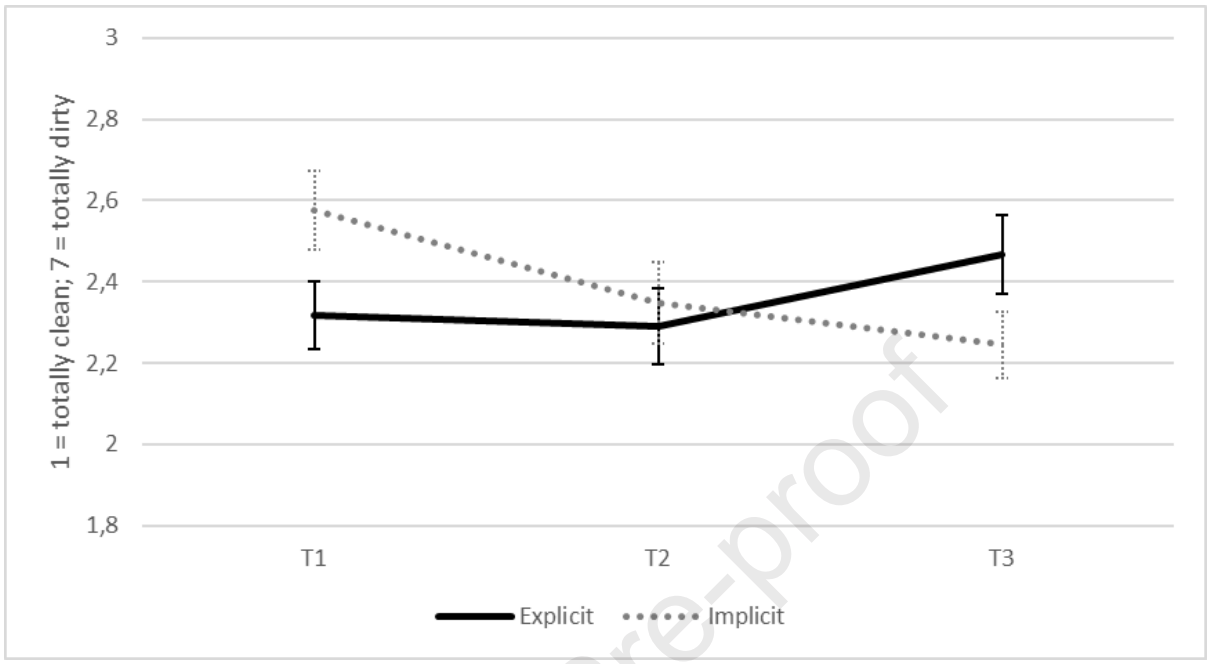
Effect of the single interventions on floor cleanness



Note: Figure displays the mean plus within-location error bar. To ensure clarity, the y-axis was shortened to 1.8 to 3.0

Figure 4

Differential effect of explicit and implicit interventions on floor cleanness



Note: Figure displays the mean plus within-location error bar. To ensure clarity, the y-axis was shortened to 1.8 to 3.0

Implicit Reminders of Reputation and Nature Reduce Littering more than Explicit Information on Injunctive Norms and Monetary Costs

Highlights

- Four interventions to reduce littering were tested in an RCT in the field
- Implicit interventions: watching eyes and a nature picture
- Explicit interventions: information on financial consequences and injunctive norms
- The RCT involved 440 waste disposal areas and lasted for seven weeks
- Soft and indirect appeals but not direct information seem to reduce littering

Author statement

Katharina Gangl designed the experiment, analyzed the data, and wrote the manuscript. Anna Walter designed the experiment and wrote the manuscript. Paul van Lange helped with interpretation of the data and writing of the manuscript.