Journal of Environmental Psychology 74 (2021) 101587

Contents lists available at ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep

# Cleaning up our acts: Psychological interventions to reduce engine idling and improve air quality

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ARTICLE INFO

*Keywords:*
Pro-environmental behavior
Field experiment
Social norm
Outcome efficacy
Self-regulation
Air quality

ABSTRACT

A large-scale field experiment tested psychological interventions to reduce engine idling at long-wait stops. Messages based on theories of normative influence, outcome efficacy, and self-regulation were displayed approaching railway crossing on street poles. Observers coded whether drivers ($N = 6049$) turned off their engine while waiting at the railway crossings (only 27.2% did so at baseline). Automatic air quality monitors recorded levels of pollutants during barrier down times. To different degrees, the social norm and outcome efficacy messages successfully increased the proportion of drivers who turned off their engines (by 42% and 25%, respectively) and significantly reduced concentrations of atmospheric particulate matter ($PM_{2.5}$) 2 m above ground level. Thus, the environment was improved through behavior change. Moreover, of both practical and theoretical significance, there was an 'accelerator effect', in line with theories of normative influence whereby the social norm message was increasingly effective as the volume of traffic increased.

## u1. Introduction

Air pollution is a major threat to human health, well-being, and the environment – especially in urban areas. Between 2014 and 2016, 74–85% of urban populations in Europe were exposed to $NO_2$ (nitrogen dioxide) above the World Health Organization threshold and 98% exceeded $O_3$ (ozone) thresholds, causing more than 500,000 deaths per year (European Environment Agency, 2018). Even short-term regular exposure to pollutants at much lower levels than current hourly limits impacts health and creates considerable cumulative risk for regular route users such as children going to school (Schultz et al., 2012). Indeed, these pollutants are especially dangerous for young children and babies (Sharma & Kumar, 2018), increasing their incidence of asthma (Weinmayr et al., 2010). In the UK, the 2018 Annual Report of the Chief Medical Officer estimated that air pollution contributes to 40,000 excess deaths each year, costing the economy around £27 billion (Davies, 2018).

Motor traffic is a major air pollutant in urban areas, releasing $NO_2$, $O_3$, and $PM_{2.5}$ (particulate matter with a diameter of less than 2.5 μm) and contributing significantly to greenhouse gas emissions (Dietz et al., 2009). Reducing exhaust emissions from idling engines is particularly important because the PM, $CO_2$ and $NO_2$ do not disperse quickly, reducing local air quality and directly causing of respiratory and heart problems (Shancita et al., 2014). Importantly, idling is a prevalent

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https://doi.org/10.1016/j.jenvp.2021.101587
Received 30 April 2020; Received in revised form 22 December 2020; Accepted 11 March 2021
Available online 15 March 2021
0272-4944/

behavior that is potentially amenable to cost effective forms of immediate influence. In this project, we developed interventions based on psychological theory and research to motivate drivers to turn off their idling engine.

Previous research demonstrated the feasibility of using persuasive messages to influence engine idling rates. Several small field studies investigated drivers' willingness to turn off their engine while waiting for 2–3 min at a railway crossing, and found some persuasive messages to efficiently reduce engine idling, by up to 25% (Mahmood et al., 2019; Meleady et al., 2017; Player et al., 2018; Van de Vyver et al., 2018). However, these studies have all relied on the presence of a research assistant to display the messages, which could have created demand effects. In addition, messages were only visible during data collection which may have increased their salience above that of permanent signs.

Reductions in engine emissions are important at the global level, but the details of specific contexts also matter for designing practical interventions. Previous studies have not quantified whether using road signs to reduce engine idling did actually improve air quality in the specific locations as a result of behavioral change. In order to persuade traffic planners to use such methods, place-based interventions need to be able to demonstrate whether changes in the numbers of cars with idling engines materially and directly affect air quality for people in the immediate vicinity. Such impact might depend on other factors such as weather conditions, road width, building heights and so on, any of which might exacerbate or ameliorate the effect of engine idling on the air people are breathing in that vicinity. Thus, to understand the potential value of interventions to reduce engine idling within the area it is particularly valuable to know whether there is a clear impact on pollutants people will inhale in the immediate vicinity.

### 1.1. Present research

The present research, conducted in the city of Canterbury, UK, addresses these limitations in a much larger scale experiment to test the relative impact of three theory-based persuasive messages that were at fixed locations near railway crossings and displayed continuously for several days. Moreover, we conducted continuous air quality monitoring during barrier drop times. Many different psychological constructs can be highlighted in persuasive messages (e.g., values, norms, emotions). We chose here to focus on constructs that had already been tested and proven most effective in different prior studies using persuasive messages at railway crossings. Specifically, we selected and refined messages focusing on outcome efficacy (Mahmood et al., 2019), self-regulation (Meleady et al., 2017), and social norm (Player et al., 2018).

#### 1.1.1. Outcome efficacy

Outcome efficacy (or expectancy) represents the beliefs that performing a behavior will lead to positive outcomes (Hausenblas et al., 1997; McEachan et al., 2011).[1] It is conceptually distinct from self-efficacy, which is defined as the perceived ease of performing a behavior within one's control (Bandura, 1977; see also Williams, 2010). Turning off an engine should be perceived as relatively easy and controllable (i.e., high self-efficacy) but drivers may doubt that it will affect air quality (low outcome efficacy). Hence, outcome efficacy is a more relevant construct for this context. People are often discouraged from making personal effort to engage in pro-environmental behavior (PEB), because it feels like a 'drop in the ocean' (Lorenzoni et al., 2007). However, belief that individual actions can contribute to tackle larger environmental issues results in greater PEB (Doherty & Webler, 2016; Lindsay & Strathman, 1997). In the same vein, participative efficacy (the belief that one's individual actions would contribute to the positive change) was found to predict environmental activism intentions more strongly than self-efficacy or group efficacy (Bamberg et al., 2015). In order to increase outcome efficacy amongst drivers at a railway crossing, Mahmood et al. (2019) created a message that asked, "Please switch off your engine when barriers are down. You will improve air quality in this area". We therefore presented a similar message in the present research.

#### 1.1.2. Self-regulation

Self-focused attention is a process required for self-regulation and may be directed either to public aspects (i.e., "the part of the self which is concerned with the recognition or regard received from others"; Fenigstein, 1987, p. 548) or private aspects (one's "inner being, their cognitive faculties, their emotional states, their desires and intentions"; Fenigstein, 1987.). Contextual cues can direct attention to one or other aspects. Public self-focus decreases intrinsic motivation (Plant & Ryan, 1985) whilst increasing compliance. But in situations that are perceived as coercive, private self-focus decreases compliance (Froming & Carver, 1981) and increases reactance (Carver & Scheier, 1981). Importantly, private self-focus increases consistency between personal values and their public expression (Scheier, 1980). Meleady et al. (2017) compared the effect of a general surveillance cue that was expected to induce public self-focus (watching eyes stimulus) and a private self-focus manipulation ("think of yourself") on drivers' willingness to turn off the engine. Only the latter had a positive impact, highlighting the effectiveness of engaging the self when trying to instigate self-regulatory action, and also suggesting that cues evoking *self*-surveillance could be more effective than cues implying *external* surveillance. In the present research, we drew from Meleady's private self-focus message but adapted it slightly to put more emphasis on people's actions: "Think about your actions. When the barriers are down please turn off your engine."

#### 1.1.3. Social norms

Research on social influence has shown that people tend to conform to the norms of their ingroup, notably regarding PEB (e.g., Emeakaroha et al., 2014; Nolan et al., 2008; Schultz et al., 2008). Specifically, prescriptive norms (that highlight socially desired behavior) and moral norms (a person's sense of obligation) have been identified as important determinants of action (e.g., Cialdini et al., 2006), notably for conservation behavior (Kaiser et al., 2005) and purchase of green food products (Arvola et al., 2008; Gleim et al., 2013). Player et al. (2018) directed drivers' attention to an ingroup norm to turn off their idling engine. This was effective in reducing engine idling. In the present research we highlighted an ingroup norm of acting responsibly, with the message, "Join other responsible drivers in Canterbury. Turn off your engine when the barriers are down."

Prior research suggests that norms become more influential when people are aware of being observed by other ingroup members (Abrams & Hogg, 1990), and it seems probable that drivers who all have to stop at the same time to wait for a passing train do feel like an entitative group (Lickel et al., 2001). Given that accountability to others is likely to be higher when there are more others present, we anticipated more compliance to the social norm message when traffic queues included larger numbers of vehicles. This is akin to a concept from economics known the 'accelerator effect' (Bernanke et al., 1999), whereby increasing GDP results in greater capital investment by business.

In the present context an accelerator effect is in the form that as numbers in the queue increase normative pressure should become increasingly effective, creating a virtuous cycle where compliance and

[1] A reviewer pointed out that the manipulation used for outcome efficacy could also be described as 'effectiveness knowledge' (Frick et al., 2004). From our perspective, however, the key is that the message removes uncertainty about whether the behavior will have an effect. Of course, we cannot be sure that all drivers care about that effect or regard it as important enough, although its importance is implied by the very presence of the sign. Thus, we believe that the message appropriately served the purpose of removing any doubts in drivers' minds about the link between turning off their engines and consequent air quality.

air quality should both improve. In contrast, we did not expect the number of vehicles to affect the impact of the outcome efficacy message. Moreover, self-directed attention seemed likely, if anything, to reduce attention to the other vehicles. Therefore, we expected either an attenuating effect or no effect of increased traffic volumes in the self-regulation condition.

#### 1.1.4. Overview of the present research

In light of these previous findings, we conducted a large-scale field experiment and assessed the efficacy of the three persuasive messages in persuading drivers to turn off their idling engine. The research was conducted Canterbury, in the south east of England, a small city that had been identified as an Air Quality Management Area (i.e., one in which pollution levels were consistently above thresholds determined by the UK Government's Department for the Environment, Food and Rural Affairs as requiring action). We assessed a baseline level of compliance (no message presented) against which we compared each of the intervention messages. We expected all three messages to increase compliance as compared to baseline but we were agnostic regarding the relative impact of the messages and tested differences between messages in an exploratory fashion. We also tested for the presence of an accelerator effect. Moreover, we monitored the levels of air pollution at the railway crossings during barrier down times ($O_3$, $NO_2$, and $PM_{2.5}$) and explored the impact of the intervention messages on these levels.

In addition to the field experiment, we conducted an online study in order to assess face validity of the messages and to investigate how they were generally perceived by drivers. In summary, this online study supported the hypothesis that the messages have good face validity, as respondents were correctly able to link each message with the appropriate definition of the underlying relevant psychological construct. The study also confirmed that when asked to imagine seeing these messages respondents expressed a higher intention to switch off their engines than in a control condition with no message. Detailed results of the pilot are reported in Supplemental Online Material (SOM1).

## 2. Method

### 2.1. Data collection

The methodology received approval from the Psychology Ethics Panel at the University of Kent. Informed consent was not feasible as this was an observational study. However, no personal data were collected and all participants remained completely anonymous. The total sample consisted of 6533 vehicles travelling across two railway crossings in a UK city in the summer of 2018. The testing period ran from the first week of July to the first week of August. No sign was put up during the first week, which served as the baseline to allow assessment of the average rate of engine idling behavior prior to the intervention. During the following weeks, three different road signs were each displayed for one week, and were changed every Monday. The signs at the two locations were never the same during any particular week, and they were presented in a rotating sequence (see details in SOM2). The testing period ran from every Tuesday to Thursday at 3 time intervals each day: 9–10am, 1–2pm, and 5–6pm.

During railway crossing barrier down times, two researchers manually recorded engine idling for all vehicles from the barrier to the end of the queue of traffic (or as many as possible before the barriers were raised). They were trained and instructed to avoid eye contact with drivers and walk continuously as they coded the vehicles in order to avoid attracting attention. One or two instances occurred when drivers asked what the researchers were doing, to which they had been instructed to respond a 'traffic observation study'. As traffic censuses were not uncommon in the city, drivers may have inferred this referred to traffic volume, speed and type, and so it did not seem likely to create any particular demand characteristics. We recorded the number of vehicles in the queue (range: 4 to 59 vehicles; $M = 26.7$, $SD = 9.84$). We also recorded the type of vehicle (car, bus, lorry, motorbike, van/service vehicle, or taxi), as well as duration and timing of the barrier drops. Across the study, multiple assistants helped with data collection, and almost all collected data from all four positions (2 locations × 2 directions) to guard against any coder biases. At any one measurement period, two researchers were at each location, one on each side of the crossing.

The two railway crossings are approximately 1 mile away from each other (crossing the same train line). Although both crossings are within the city limits and on relatively busy roads, one is a bit more city-centered and surrounded by more buildings than the other. In general, traffic to and from the city would use one or other but not both of these routes (i.e., drivers would either make one crossing while passing through the city or make a return trip using the same crossing. Preliminary analyses revealed that average temperature and humidity (see below) differed between the two sites, presumably due to the different surroundings (respectively, temperature: $b = .68$, $SE = 0.05$, 95% CI [0.59, 0.77], $t(5877) = 14.42$, $p < .001$; humidity: $b = 2.71$, $SE = 0.07$, 95% CI [2.57, 2.84], $t(5869) = 39.73$, $p < .001$. The average volume of traffic was also greater at the more central location, $b = 1.83$, $SE = 0.16$, 95% CI [1.51, 2.14], $t(6228) = 11.41$, $p < .001$. To account for potential differences between sites, we controlled for Location in all following analyses and note here that the effect of the interventions did not differ from one location to the other.

Some data were incomplete (e.g., the date or time was not recorded, or pollutant levels data were missing for the time of a barrier drop). We focused our analyses on complete data, resulting in a final sample size of 6049 vehicles (see Table 1; the complete breakdown of vehicle type by Location and Condition can be found in SOM3). Overall, 32.1% of drivers turned off their engine. The sample size was partly determined by the volume of traffic and fixed timing for the interventions; moreover, we adopted a conservative approach ensuring that the N would be sufficient to detect small effect sizes. Specifically, power analyses by simulation (package *simr*, Green & MacLeod, 2016, pp. 1000 bootstraps simulations) indicated that the sample size was sufficient to detect a main effect of Condition of $b = 0.065$ at 0.81 power, 95% CI [0.79, 0.84] (equivalent to $OR = 1.07$). For a Condition × Number of vehicles in the queue, the simulation indicated that the sample size was sufficient to detect an effect of $b = 0.005$ at 0.88 power, 95% CI [0.86, 0.90].

Past research testing the impact of persuasive messages at railway crossings has focused only on car drivers, based on the possibility that they had more autonomy over their driving behavior (whereas, for example, to taxi or bus drivers may be subject to company policies or the influence of paying passengers). However, because the present research considered not only drivers' behavior but also the consequence for concentrations of air pollutants near the crossing, it made more sense to include all vehicles in the analyses. A precautionary analysis, focusing only on car drivers, yielded similar results, as shown in SOM4.

### 2.2. Intervention road signs

The intervention signs were printed on 60 cm × 45 cm, black text over yellow background, designed to stand out against white road signs already present. They were fixed to lampposts, 2.5 m above the ground. Three different intervention signs, displaying different messages, were used (baseline: $n = 1458$):

- Social norm message: "Join other responsible drivers in Canterbury. Turn off your engine when the barriers are down" ($n = 1356$)

**Table 1**
Composition of the retained sample, by type of vehicle.

| | Car | Bus | Lorry | Motorcycle | Van/service vehicle | Taxi |
|---|---|---|---|---|---|---|
| *N* | 4937 | 115 | 94 | 32 | 723 | 148 |
| *%* | 81.6% | 1.9% | 1.6% | 0.5% | 11.9% | 2.4% |

- Outcome efficacy message: "Turn off your engine when the barriers are down. You will improve air quality in the area" ($n = 1614$)
- Self-regulation message: "Think about your actions. When the barriers are down please turn off your engine" ($n = 1621$)

### 2.3. Air pollution levels

Separate automated recording was conducted to monitor air quality. Specifically, EarthSense Zephyr Air Quality Sensors were used to measure concentration of air pollution. The sensors measured temperature (in °C), humidity (in %), and the level of $NO_2$, $O_3$, and $PM_{2.5}$ (μg/m$^3$). Each sensor was calibrated by the manufacturer by co-locating it with a local authority reference site, giving a stated accuracy of ± 5 μg/m$^3$ for $NO_2$ and $PM_{2.5}$, and ± 8 μg/m$^3$ for $O_3$. The sensors were attached to a lamppost at the side of the road where traffic was heading towards the railway crossings, roughly 2 m above the ground, and approximately 30 m from the railway crossings. The sensors provided readings every 10 s. We retrieved and averaged the readings corresponding to each barrier drop (i.e., from the time the barriers went down to the time they went up again). Descriptive statistics are reported in Table 2. Sample pictures of the two crossings are shown in Figs. 1 and 2.

### 2.4. Analytic strategy

#### 2.4.1. Behavioral data

The present data are organized in a hierarchical nested structure, with 6049 observations collected during 257 sessions (or barrier drops) across 17 observation days and 2 locations. Given their non-independent nature, we relied on multilevel regressions including sessions and days as random factors (ICC = 0.003) as well as Location. In all analyses, we controlled for air temperature and humidity, and also considered the number of vehicles queuing at the railway crossing. These continuous variables were grand-mean centered. The intervention messages variable was entered as a categorical factor with "baseline" = 0, "social norm" = 1, "outcome efficacy" = 2, and "self-regulation" = 3, so that the effect of each message would be compared to the baseline. Analyses were conducted on RStudio with the *lme4* (Bates et al., 2019) and *lmerTest* packages (Zeileis & Hothorn, 2002), following guidelines by Sommet and Morselli (2017). When appropriate, we report odds ratios (OR) and their 95% confidence interval, alongside other statistics. Behavior was dummy coded so that "did not turn off the engine" = 0 and "turned off the engine" = 1. The following model was tested, using the function *glmer*, family = "binomial" (i.e., multilevel logistic regression, two-sided test):

Engine off ~ Condition + Number of vehicles + Temperature + Humidity + Location + Condition*Number of vehicles + (1 | Day/Session)

We initially ran both the constrained intermediate model (CIM; random intercept only) and the augmented intermediate model (AIM; random intercept and slope) and compared them. The likelihood ratio test showed that the AIM did not significantly improve the fit of the model, as compared to the CIM, $\chi^2(df = 20) = 8.25$, $p = .99$. We hence kept the simpler CIM model for further analyses.

#### 2.4.2. Air pollution data

The monitors registered ambient levels of $O_3$, $NO_2$, and $PM_{2.5}$, three pollutants that are known to be affected by traffic but also by many other factors. We hence started by testing whether the recorded levels were sensitive to the volume of traffic present at the railway crossing (i.e., sensitivity analyses). If the monitors proved unable to detect traffic-related variations, it would be irrelevant to pursue the analyses further. We used the data recorded at baseline during barrier drops (with no message present) to test whether the number of vehicles in the queue would impact the recorded levels of $O_3$, $NO_2$, and $PM_{2.5}$. These analyses were exploratory. Because the distributions were skewed (1.35 < skewness index < 2.7; 2.67 < Kurtosis <13.3), we first applied a logarithmic transformation on the data. We took into account the nested structure of the data and controlled for temperature and humidity (function *lmer*):

Log10 Pollutant level ~ Number of vehicles + Temperature + Humidity + (1 | Day/Session)

Not surprisingly, all pollutant concentration levels strongly depended on air temperature and humidity. More relevant for the present purposes, levels of $PM_{2.5}$ (but neither $O_3$ or $NO_2$) were found to increase when the volume of traffic increased, $b = 0.005$, $SE = 0.001$, 95% CI [0.004, 0.006], $t$ (1308) = 12.55, $p < .001$. Hence, we next tested whether the intervention messages, by reducing idling at the railway crossings, would also succeed in reducing $PM_{2.5}$ concentration levels.

The following model was used on levels of air pollution (concentration of $PM_{2.5}$), testing the impact of intervention message, number of vehicles in the queue, and their interaction, while controlling for temperature and humidity (multilevel linear regression, function *lmer*, two-sided test):

Log10 p.m.$_{2.5}$ ~ Condition + Number of vehicles + Temperature + Humidity + Location + Condition*Number of Vehicles + (1 | Day/Session)

## 3. Results

### 3.1. Behavioral data: probability that the drivers turn off the engine

The analysis revealed that the social norm message significantly increased (by 42%, or 11.5 percentage points increase) the probability that drivers would turn off their engine, as compared to the baseline, $b = 0.51$, $SE = 0.11$, 95% CI [0.29, 0.73], $z = 4.58$, $p < .001$, OR = 1.66, 95% CI [1.34, 2.07]; and so did, although to a lesser extent (25%, or 4.6 percentage points increase), the outcome efficacy message, $b = 0.25$, $SE = 0.11$, 95% CI [0.04, 0.46], $z = 2.36$, $p = .018$, OR = 1.29, 95% CI [1.04, 1.59]. The self-regulation message was not significantly different from baseline, $b = 0.20$, $SE = 0.11$, 95% CI [-0.02, 0.42], $z = 1.82$, $p = .068$, OR = 1.22, 95% CI [0.98, 1.52] (10%, or 2.7 percentage points difference). A follow-up analysis revealed that the social norm message was more effective than the outcome efficacy and the self-regulation messages, $b = -.09$, $SE = 0.03$, 95% CI [-0.15, −0.04], $z = -3.54$, $p < .001$, while the latter did not significantly differ from each other, $b = -0.03$, $SE = 0.05$, 95% CI [-0.13, 0.08], $z = -0.48$, $p = .63$ (see Fig. 3).

There was also a main effect of the number of vehicles in the queue, $b = -.01$, $SE = 0.01$, 95% CI [-0.02, −0.003], $z = -2.49$, $p = .013$, such that idling increased when the number of vehicles increased. Most interestingly, there was also a significant experimental condition by number of vehicles interaction, indicating that the effect of the number of vehicles differed in the social norm and the baseline condition, $b = 0.02$, $SE = 0.01$, 95% CI [0.01, 0.04], $z = 2.75$, $p = .006$ (see Fig. 4). The complete analysis output can be found in SOM5, alongside additional figures depicting the unstandardized number of vehicles in the queue.

We hence decomposed the interaction to explore the differences between Conditions at higher and lower volume of traffic. Decompositions indicated that when fewer vehicles were present (Number of vehicles −1 *SD*), only the social norm message managed to increase compliance as compared to baseline, and only to a small extent, OR = 1.32, 95% CI [1.00, 1.75], $p = .049$ (outcome efficacy: OR = 1.14, 95%

[2] Although $PM_{2.5}$ concentration levels might descriptively seem high in the social norm condition when the number of vehicles was low (-1*SD*), it should be noted that this was not significantly different from baseline, $b = 0.15$, 95% CI [0.009, 0.29], $t = 2.01$, $p = .064$.

**Table 2**
*Average air pollutant levels, temperature, and humidity, during the barrier drops at the two railway crossings.*

| | Temperature (°C) | Humidity (%) | $NO_2$ (μg/m$^3$) | $O_3$ (μg/m$^3$) | $PM_{2.5}$ (μg/m$^3$) |
|---|---|---|---|---|---|
| *M (SD)* | 32.1 (4.22) | 32.8 (6.64) | 20.6 (18.4) | 93.5 (24.4) | 7.12 (4.35) |
| *min – max* | 23.0–46.0 | 20.8–52.3 | 0–182.8 | 39.1–219.5 | 3.00–24.1 |

**Fig. 1.** St Stephens railway crossing showing queuing traffic as the barriers lower during the baseline period.


**Fig. 2.** St Dunstans railway crossing showing queuing traffic as the barriers lower, and the self-regulation intervention sign.

CI [0.86, 1.49], $p = .36$; self-regulation: OR = 1.18, 95% CI [0.91, 1.55], $p = .21$). These translate in relative increase of compliance of, respectively, 18.8%, 10.8%, and 2.0% as compared to baseline. In contrast, when more vehicles were present (Number of vehicles +1 *SD*), the relative effectiveness of the messages as compared to the baseline increased. This was especially true of the social norm message, OR = 2.09, 95% CI [1.60, 2.74], $p < .001$ (outcome efficacy: OR = 1.46, 95% CI [1.14, 1.87], $p = .003$; self-regulation: OR = 1.26, 95% CI [0.96, 1.66], $p = .100$). These translate in relative increase of compliance of, respectively, 63.6%, 31.7%, and 7.5% as compared to baseline. Described differently, in the baseline condition, as the number vehicles increased, a higher proportion continued to idle, OR = 1.35, 95% CI [1.11, 1.64], $p = .003$. In the social norm condition, however, as the number of vehicles increased, a lower proportion continued to idle, OR = 0.74, 95% CI [0.64, 0.86], $p < .001$. In the self-regulation and outcome efficacy conditions, the number of vehicles had no effect on the proportion that continued idling, respectively, OR = 1.03, 95% CI [0.80, 1.33], $p = .79$, and OR = 1.15, 95% CI [0.98, 1.34], $p = .079$.

### 3.2. *Air pollutant concentration levels*

Consistent with preliminary sensitivity analyses (see Method

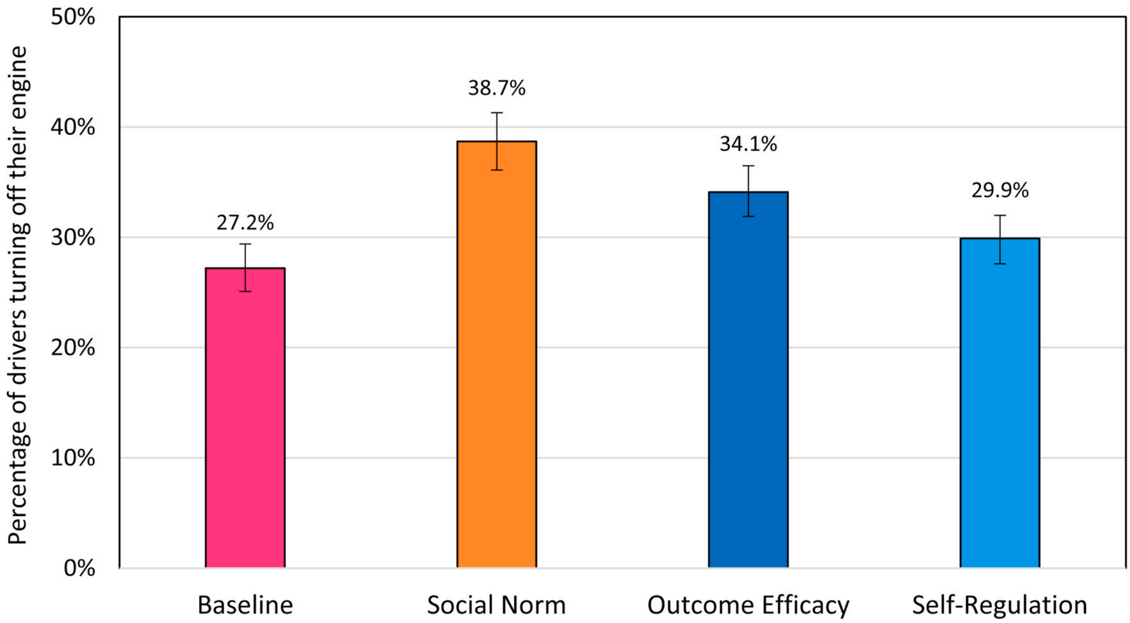


**Fig. 3.** Percentage of drivers turning off their engine while waiting at the railway crossing, depending on the experimental condition. Error bars represent 95% CI (1000 bootstrap samples).

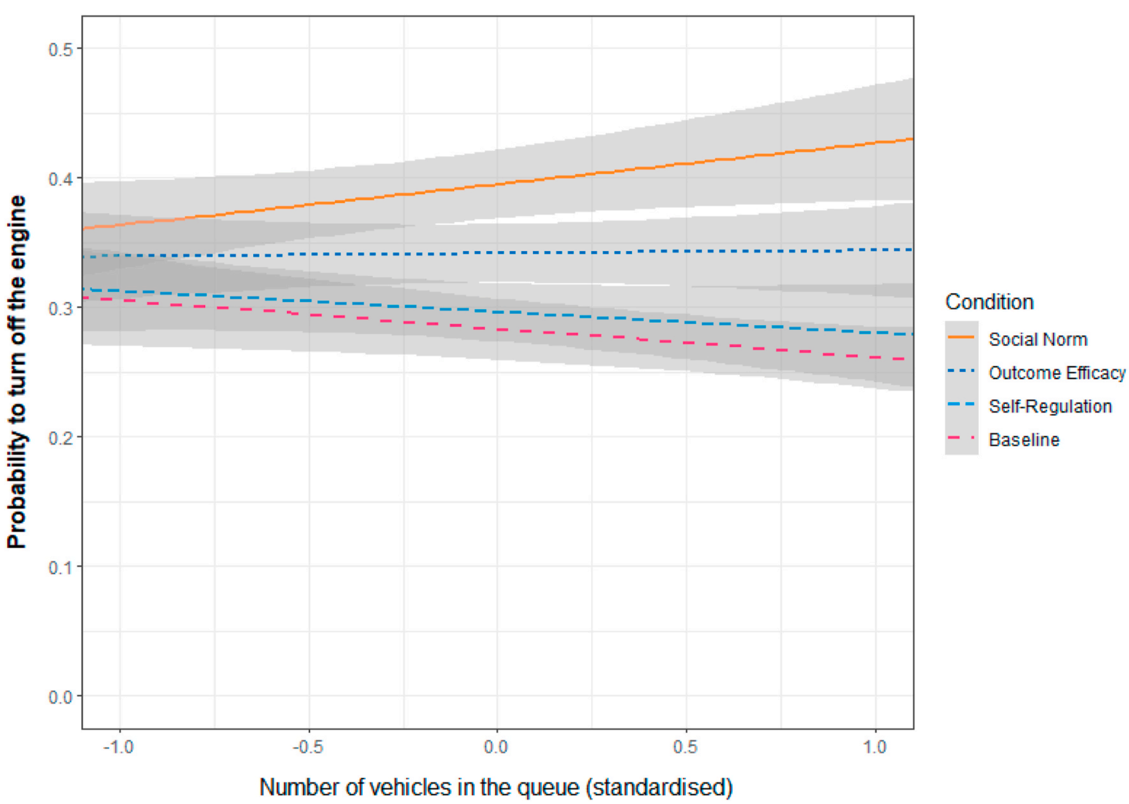


**Fig. 4.** Probability that the drivers turn off their engine as a function of the intervention message and the number of vehicles in the queue (standardized score, from −1 *SD* to +1 *SD*). These represent marginal probabilities calculated while controlling for temperature and humidity. Grey zones represent 95% confidence intervals.

section), concentration level of $PM_{2.5}$ was strongly impacted by temperature, $b = 0.06$, 95% CI [0.06, 0.07], $t = 32.56$, $p < .001$, humidity, $b = 0.02$, 95% CI [0.02, 0.02], $t = 11.78$, $p < .001$, and number of vehicles in the queue, $b = 0.001$, 95% CI [0.0003, 0.002], $t = 2.91$, $p = .004$. There was no main effect of condition, $t_s < |1.99|$, $p_s > .06$ (the complete analysis output can be found in SOM6). However, the analysis revealed significant message × number of vehicles interactions, indicating a differential impact of the number of vehicles in the social norm, $b = -0.004$, 95% CI [-0.005, −0.003], $t = -8.82$, $p < .001$, and the outcome efficacy condition, $b = -0.002$, 95% CI [-0.003, −0.001], $t = -4.48$, $p < .001$, as compared to the baseline (see Fig. 5).

As previously, we decomposed the interaction to explore the links between volume of traffic and $PM_{2.5}$ across conditions. As found in preliminary sensitivity analyses, $PM_{2.5}$ concentration levels increased

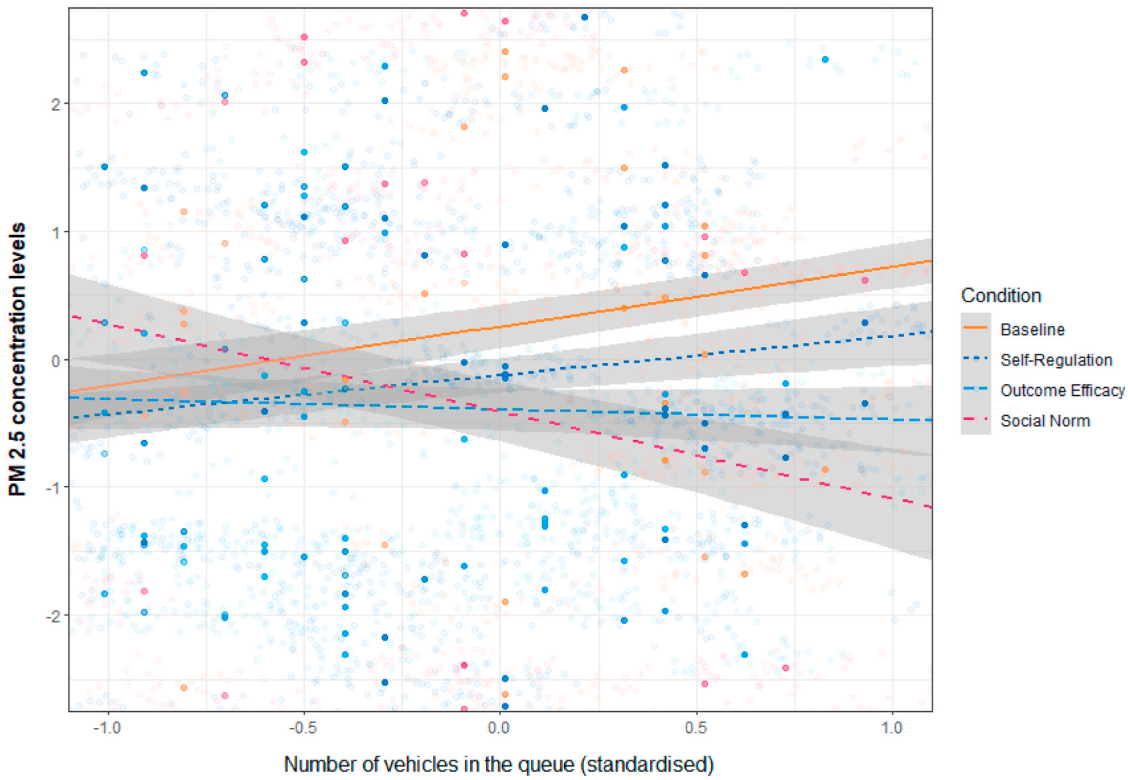


**Fig. 5.** Concentration levels of $PM_{2.5}$ as a function of the intervention message and the number of vehicles in the queue (standardized score, from −1 *SD* to +1 *SD*). These represent marginal values calculated while controlling for temperature and humidity. Grey zones represent 95% confidence intervals.

with the amount of traffic at baseline. This link, however, became null in the self-regulation, $b = 0.002$, 95% CI [-0.001, 0.005], $t = 1.14$, $p = .26$, and outcome efficacy conditions, $b = -0.001$, 95% CI [-0.002, 0.0004], $t = -1.43$, $p = .15$. It even reversed in the social norm condition: $PM_{2.5}$ concentration decreased when the amount of traffic increased, $b = -0.007$, 95% CI [-0.008, −0.005], $t = -8.98$, $p < .001$. As a result, $PM_{2.5}$ levels significantly dropped as compared to baseline in the social norm and outcome efficacy conditions when traffic was heavy (social norm: $b = -0.21$, 95% CI [-0.35, −0.07], $t = -2.84$, $p = .013$; outcome efficacy: $b = -0.18$, 95% CI [-0.32, −0.04], $t = -2.37$, $p = .032$; self-regulation: $b = -0.01$, 95% CI [-0.25, 0.05], $t = -1.26$, $p = .23$). In contrast, when the number of vehicles was low (-1*SD*), $PM_{2.5}$ concentration levels in the different intervention conditions were not different from baseline, $b = 0.03$, 95% CI [-0.01, 0.06], $t = 1.59$, $p = .14$.2 This suggests that the effect of the interventions was most visible when the volume of traffic, and with it the potential emissions or air pollutants, increased.

## 4. Discussion

This large-scale field experiment assessed the effectiveness of three interventions (outcome efficacy, self-regulation, and social norm messages) designed to decrease engine idling. We observed whether the drivers turned off their idling engine while waiting, and we also recorded air quality at the railway crossings. The social norm and outcome efficacy messages reduced engine idling rates compared to baseline, by up to 42%. The self-regulation message only led to small variations. These behavioral changes translated into a reduction in $PM_{2.5}$ concentrations while drivers were waiting for barriers to rise at railway crossings. Hence, this research demonstrated that using psychologically relevant messages on road signage can successfully reduce engine idling and improve air quality.

This research fills important gaps in our knowledge (Mahmood et al., 2019; Meleady et al., 2017; Player et al., 2018). First, as far as we know, this is the first research to show that behavioral change induced by persuasive messages translates into observable changes in air quality and pollutant concentration levels. The translation from a psychological intervention to behavior change and to consequent environmental impact validates the theoretical premises and practical value of the research.

### 4.1. An accelerator effect of the normative message

Second, we were able to show a psychologically meaningful increase in impact as a function of the volume of traffic (the number of stationary vehicles). In the absence of any intervention, the percentage of drivers that left their engine idling increased with traffic volume. Various psychological theories suggest that people regulate their own actions less when immersed in a larger group, owing to deindividuation (Postmes & Spears, 1998), diffusion of responsibility (Darley & Latané, 1968) and social loafing (Karau & Williams, 1993). Given the default to leave engines idling, it is likely that this "polluting" descriptive norm became more salient as the number of vehicles increased, increasing unreflective conformity to that norm (Goldstein & Cialdini, 2009). Very encouragingly, however, the impact of traffic volume was affected by particular message content.

In two conditions, the positive association between traffic volume and idling/pollution was nullified or even reversed. The outcome efficacy message prevented the (otherwise negative) impact of traffic volume, creating a stable compliance rate. This suggests that drivers understood the message as pertaining to their own behavior independently from others', which mitigated the diffusion of responsibility effect. More dramatically, when we presented a prescriptive social norm message, a greater the number of vehicles in the queue was accompanied by *increased compliance*, and reduction in pollution levels. Thus, the presence of larger numbers of other drivers boosted the impact of the message (cf. Latané & Wolf, 1981). In other words, we established an accelerator effect due to the social norm message.

It could be argued that the accelerator effect of the social norm manipulation arises simply because the normative message cues attention to social norms per se (without regard to content). By this reasoning, if the first car in the queue ceases to idle, this leads to a domino effect as each subsequent car follows suit, matching to the behavior of the vehicle immediately ahead (it being unlikely they could see or hear beyond that). However, because this effect is contingent on there being no breaks in the chain, it might as easily result in no substantial change in mean levels of engine idling but perhaps a more bimodal pattern where almost all or almost no drivers cease idling, dependent on the actions of the first few cars in the queue.

A cumulative norm of this sort might also be analogous to the way dynamic norms work. Dynamic norms have conventionally been manipulated by informing people that a growing (or reducing) number rather than a static number of others are adopting a particular behavior (e.g., meat consumption, Sparkman & Walton, 2017; and use of reusable rather than disposable coffee cups, Loschelder et al., 2019). In principle, dynamic norms are influential because people are thought to be more sensitive to changes in behavior (in the present instance, others turning off their engines) than to descriptive information about the frequency of behavior. However, we are not aware of any tests of dynamic norms that use actual behavior change rather than information about norm change as the cue.

In the present study, the normative message "Join other responsible drivers" merely highlighted a static norm. It will be interesting for future research to explore whether a static normative message in combination with a behavioral dynamic is also a powerful combination. In the present case, a driver who would habitually stop idling regardless of the presence of the message provides a cue to second driver who may infer this as a behavioral response induced by the message. This combined salience of cues with convergent behavioral implications may then be a potent way to encourage conformity from the second driver.

### 4.2. Similarities and differences with previous findings

Compared with previous studies testing persuasive messages at railway crossings, the present study provided substantially larger sample sizes, and thus ensured higher power. This enabled us to detect more nuanced effects, such as the interaction between the number of vehicles and impact of the message. In addition, we showed a reliable overall effect of the normative message, which had not always been the case in previous studies. In Mahmood et al. (2019), a prescriptive message focusing on reputation management ('Show others you care') did not significantly increase compliance compared to baseline. However, the level of compliance observed (38.7%) was comparable to that of the normative message in the present study (38.1%). The lack of statistical significance in Mahmood and colleagues' study might then be attributable to a relative lack of power to identify small effects. Other studies relied on slightly different social norm messages, which have led to variations in the results. For example, Player et al. (2018) tested a descriptive norm message "When barriers are down 25% of motorists turn off their engines!", which resulted in 41% compliance (statistically significant). This seemingly slightly greater impact of descriptive (rather than prescriptive) norms is consistent with previous work that documented a more consistent effect of descriptive norms than prescriptive norms in motivating pro-environmental behavior (Farrow et al., 2017).

Unexpectedly, the self-regulation message only had a small effect on compliance, despite proving effective in previous research (see Meleady et al., 2017). The presence of many others may have been a contextual cue drawing attention to the public rather than private self, hence decreasing the impact of the self-regulation message (Plant & Ryan, 1985). Alternatively, this message may not have induced any process different from the baseline. Another explanation may lie in the framing of the messages. In the present study, the message, "Think about your actions. When the barriers are down please turn off your engine", was intended to direct people's attentions to their behavior, but it also may have been perceived as moralizing or paternalistic. Moralization of pro-environmental issues might lead to defensiveness, reactance or disengagement, especially amongst individuals who are not engaged with the issue (Täuber et al., 2015). This framing might have counteracted the self-regulation aspect of the message. By contrast, Meleady and colleagues asked people to "Think of yourself ..." which involved no moral overtone and, by already implying autonomy, may simply have activated self-regulation without any resistance or reactance to the instruction to switch off the engine. Such subtle variations would need to be investigated further in future research. Finally, it should be noted that "think about your actions" might have activated an environmental goal only amongst people who hold such a goal. In principle, other self-regulatory goals (e.g., to avoid wastefulness) could promote the same behavior. Indeed, messages appealing to financial self-interest effectively increased the percentage of drivers turning off their engine at a railway crossing (Van de Vyver et al., 2018). However, the message could also have made other self-regulatory goals salient (e.g. personal comfort, desire to be ready to set off quickly as soon as possible), resulting in no overall decrease in engine idling.

Thirdly, turning to outcome efficacy, as noted earlier the manipulation was designed to increase the perceived effectiveness of the individual action, i.e., to remove uncertainty about whether turning off the engine would affect air quality. The message conveyed factual information about the outcome (i.e., "you *will* improve air quality") rather than focusing on individual capability ("you *can* improve air quality"). This approach was used because efficacy to conduct the relevant behavior (or self-efficacy) was never in doubt: all drivers feel they can switch off their ignition at will. We therefore focused on outcome efficacy, or the belief in the impact of the individual action (Williams, 2010). It could be debated whether this is best conceptualized as effectiveness knowledge (Frick et al., 2004) or outcome efficacy. Regardless, in our view the objective is the same, namely, to remove doubt about the impact of behavior on air quality.

Finally, an important finding is that we can now be more confident that the presence of a human communicator is not necessary for these persuasive interventions to be effective. In previous studies research assistants held the signs (Meleady et al., 2017; Player et al., 2018; Mahmood et al., 2019). Although the impact of the messages is somewhat lower in the present than in past research (see Table 3), the present evidence has much greater statistical power and indicates that an important part of the effect, at least for outcome efficacy and norms, can be imputed to the message itself and not the presence of a person to display it.

### 4.3. Conclusions and avenues for future research

The present research offers a substantial field test of psychologically informed interventions to reduce engine idling. It demonstrated the effectiveness of messages focusing on outcome efficacy and norms. A particularly important finding is that the norm manipulation not only reduced engine idling but also improved air quality more as the volume of traffic increased, thereby reducing harmful emissions precisely when it was most urgent to do so.

Future research should examine interventions monitored over longer periods of time and could examine impacts on more chronic and diffuse components of air quality that are less susceptible to moment-by-moment change (such as $NO_2$ and $O_3$; Shancita et al., 2014). In the present study messages were presented continuously for five consecutive days, a timeline that is too short to assess long-term impact. Longer trial periods could help to sustain new anti-idling habits and hence reduce idling durably. However, it is also possible that efficacy might decrease with repeated exposure because drivers habituate to the presence of the road sign and pay less attention to it. A more dynamic form of signage (e.g., electric signs that vary a series of different messages) could be particularly effective, especially if sensors could adapt messages based on current traffic volume. Once set up, this would be a cost-effective and straightforward way of implementing the findings on

**Table 3**
Comparison of compliance rates (non-idling engines) in past and current research.

| | Intervention message | Past research | | Present research | |
|---|---|---|---|---|---|
| | | Compliance rate | Baseline | Compliance rate | Baseline |
| Player et al. (2018) | Social norm | 47% | 28% | 39% | 26% |
| Mahmood et al. (2019) | Outcome efficacy | 49% | 29% | 34% | 26% |
| Meleady et al. (2017) | Self-regulation | 51% | 20% | 30% | 26% |

*Note*. Previous research presented messages by having research assistants present signs on handheld poles, whereas in the present research signs were affixed to regular street poles.

message content and mitigating the risk that impact of the messages reduces owing to habituation. In addition, because the present testing was conducted in consecutive weeks with only a few days between one message and the next, we cannot exclude the possibility that there was an effect from exposure to different signs over time. Although randomizing the order of messages across the two locations relieves this concern to an extent, future studies could explore this aspect by increasing the length of time between different interventions. Similarly, although the overall testing period was quite short and within the same season, and although we controlled for temperature and weather conditions, it is possible that the baseline period was in some way different from the experimental periods in ways we had not measured.

Future studies might also explore the impact of dynamic norms, or different combinations of static and dynamic norm cues, on engine idling, building on earlier work on promoting pro-environmental behavior (Sparkman & Walton, 2017) . For example, it would be interesting to know whether a dynamic norm message, such as 'more and more drivers are choosing not to leave their engine idling' can be effective even when the behavioral norms do not match (e.g., a driver ahead in the queue leaves their engine running).

A similar scientific approach to deployment of persuasive messages could be used to encourage other behaviors related to enhancing air quality, such as the use of public transport, cycling, and so on. Enforcement methods (e.g., implementing anti-idling fees) can often elicit counterproductive behavior because they are mostly based on external motivation (Deci & Ryan, 1980). Such motivation is often only effective in the short-term. Behavior change that is achieved through persuasion and normative shifts is more likely to be sustained over the long-term. In conclusion, our findings demonstrate for the first time that psychologically derived messages can positively affect localized pollution levels by influencing drivers' behavior, particularly benefiting from an (perhaps ironically named) accelerator effect when traffic density is high and at its most deadly.

## CRediT author statement

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## Data availability statement

The data that support the findings of this study are available in the University of Kent Academic Data Repository with the identifier https://data.kent.ac.uk/id/eprint/102.

## Declaration of competing interest

None.

## Acknowledgements

Acknowledgement to Adam Britcher from the School of Psychology for technical support, and thanks to Ruth Goudie, Kelly Haynes and Richard Griffiths from Canterbury City Council for consultation regarding signage. The research was supported by a grant to The University of Kent from the UK Department for the Environment, Food and Rural Affairs, and Canterbury City Council which had no role in the conceptualization, design, data collection, analysis, decision to publish, or preparation of the manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2021.101587.

## References

Abrams, D., & Hogg, M. A. (1990). *Social identity theory: Constructive and critical advances.* Springer-Verlag Publishing.

Arvola, A., Vassallo, M., Dean, M., Lampila, P., Saba, A., Lähteenmäki, L., & Shepherd, R. (2008). Predicting intentions to purchase organic food: The role of affective and moral attitudes in the Theory of Planned Behaviour. *Appetite, 50*(2), 443–454. https://doi.org/10.1016/j.appet.2007.09.010

Bamberg, S., Rees, J., & Seebauer, S. (2015). Collective climate action: Determinants of participation intention in community-based pro-environmental initiatives. *Journal of Environmental Psychology, 43*, 155–165. https://doi.org/10.1016/j.jenvp.2015.06.006

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bates, D. M., Maechler, M., Bolker, B., & Walker, S. (2019). lme4: Linear mixed-effects models using 'eigen' and S4. Version 1.1-21 https://CRAN.R-project.org/package=lme4.

Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). Chapter 21: The financial accelrator in a quantitative busines cycle framework. *Handbook of Macroeconomics, 1*, 1341–1393. https://doi.org/10.1016/S1574-0048(99)10034-X

Carver, C. S., & Scheier, M. F. (1981). Self-consciousness and reactance. *Journal of Research in Personality, 15*(1), 16–29. https://doi.org/10.1016/0092-6566(81)90003-9

Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., & Winter, P. L. (2006). Managing social norms for persuasive impact. *Social Influence, 1*(1), 3–15. https://doi.org/10.1080/15534510500181459

Darley, J. M., & Latané, B. (1968). Bystander intervention in emergencies: Diffusion of responsibility. *Journal of Personality and Social Psychology, 8*(4, Pt.1), 377–383. https://doi.org/10.1037/h0025589

Davies, S. C. (2018). Annual report of the Chief medical officer, 2018 health 2040 – better health within reach: Department of Health and Social Care. assets publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/767549/Annual_report_of_the_Chief_Medical_Officer_2018_-_health_2040_-_better_health_within_reach.pdf. report.

Deci, E. L., & Ryan, R. M. (1980). The empirical exploration of intrinsic motivational processes. In L. Berkowitz (Ed.), *Advances in experimental social Psychology* (Vol. 13, pp. 39–80). Academic Press. https://doi.org/10.1016/S0065-2601(08)60130-6.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences, 106*(44), 18452–18456. https://doi.org/10.1073/pnas.0908738106

Doherty, K. L., & Webler, T. N. (2016). Social norms and efficacy beliefs drive the Alarmed segment's public-sphere climate actions. *Nature Climate Change, 6*, 879. https://doi.org/10.1038/nclimate3025

Emeakaroha, A., Ang, C. S., Yan, Y., & Hopthrow, T. (2014). Integrating persuasive technology with energy delegates for energy conservation and carbon emission reduction in a university campus. *Energy, 76*, 357–374. https://doi.org/10.1016/j.energy.2014.08.027

European Environment Agency. (2018). Air quality in Europe – 2018 report. Report No 12/2018 https://www.eea.europa.eu/publications/air-quality-in-europe-2018.

Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social norms and pro-environmental behavior: A review of the evidence. *Ecological Economics, 140*, 1–13. https://doi.org/10.1016/j.ecolecon.2017.04.017

Fenigstein, A. (1987). On the nature of public and private self-consciousness. *Journal of Personality, 55*(3), 543–554. https://doi.org/10.1111/j.1467-6494.1987.tb00450.x

Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences, 37*(8), 1597–1613. https://doi.org/10.1016/j.paid.2004.02.015

Froming, W. J., & Carver, C. S. (1981). Divergent influences of private and public self-consciousness in a compliance paradigm. *Journal of Research in Personality, 15*(2), 159–171. https://doi.org/10.1016/0092-6566(81)90015-5

Gleim, M. R., Smith, J. S., Andrews, D., & Cronin, J. J. (2013). Against the green: A multi-method examination of the barriers to green consumption. *Journal of Retailing, 89*(1), 44–61. https://doi.org/10.1016/j.jretai.2012.10.001

Goldstein, N. J., & Cialdini, R. B. (2009). Normative influences on consumption and conservation behaviors. In M. Wänke (Ed.), *Social psychology of consumer behavior* (pp. 273–296). Psychology Press.

Green, P., & MacLeod, C. J. (2016). Simr: an R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution, 7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Hausenblas, H. A., Carron, A. V., & Mack, D. E. (1997). Application of the theories of reasoned action and planned behavior to exercise behavior: A meta-analysis. *Journal of Sport & Exercise Psychology, 19*(1), 36–51. https://doi.org/10.1123/jsep.19.1.36

Kaiser, F. G., Hübner, G., & Bogner, F. X. (2005). Contrasting the theory of planned behavior with the value-belief-norm model in explaining conservation behavior. *Journal of Applied Social Psychology, 35*(10), 2150–2170. https://doi.org/10.1111/j.1559-1816.2005.tb02213.x

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology, 65*(4), 681–706. https://doi.org/10.1037/0022-3514.65.4.681

Latané, B., & Wolf, S. (1981). The social impact of majorities and minorities. *Psychological Review, 88*(5), 438–453. https://doi.org/10.1037/0033-295X.88.5.438

Lickel, B., Hamilton, D. L., & Sherman, S. J. (2001). Elements of a lay theory of groups: Types of groups, relational styles, and the perception of group entitativity. *Personality and Social Psychology Review, 5*(2), 129–140. https://doi.org/10.1207/S15327957PSPR0502_4

Lindsay, J. J., & Strathman, A. (1997). Predictors of recycling behavior: An application of a modified health belief model. *Journal of Applied Social Psychology, 27*(20), 1799–1823. https://doi.org/10.1111/j.1559-1816.1997.tb01626.x

Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change, 17*(3), 445–459. https://doi.org/10.1016/j.gloenvcha.2007.01.004

Loschelder, D. D., Siepelmeyer, H., Fischer, D., & Rubel, J. A. (2019). Dynamic norms drive sustainable consumption: Norm-based nudging helps café customers to avoid disposable to-go-cups. *Journal of Economic Psychology, 75*, Article 102146. https://doi.org/10.1016/j.joep.2019.02.002

Mahmood, L., Abrams, D., Meleady, R., Hopthrow, T., Lalot, F., Swift, H. J., & Van de Vyver, J. (2019). Intentions, efficacy, and norms: The impact of different self-regulatory cues on reducing engine idling at long wait stops. *Journal of Environmental Psychology, 66*, Article 101368. https://doi.org/10.1016/j.jenvp.2019.101368

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review, 5*(2), 97–144. https://doi.org/10.1080/17437199.2010.521684

Meleady, R., Abrams, D., Van de Vyver, J., Hopthrow, T., Mahmood, L., Player, A., Lamont, R., & Leite, A. C. (2017). Surveillance or self-surveillance? Behavioral cues can increase the rate of drivers' pro-environmental behavior at a long wait stop. *Environment and Behavior, 49*(10), 1156–1172. https://doi.org/10.1177/0013916517691324

Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2008). Normative social influence is underdetected. *Personality and Social Psychology Bulletin, 34*(7), 913–923. https://doi.org/10.1177/0146167208316691

Plant, R. W., & Ryan, R. M. (1985). Intrinsic motivation and the effects of self-consciousness, self-awareness, and ego-involvement: An investigation of internally controlling styles. *Journal of Personality, 53*(3), 435–449. https://doi.org/10.1111/j.1467-6494.1985.tb00375.x

Player, A., Abrams, D., Van de Vyver, J., Meleady, R., Leite, A. C., Randsley de Moura, G., & Hopthrow, T. (2018). "We aren't idlers": Using subjective group dynamics to promote prosocial driver behavior at long-wait stops. *Journal of Applied Social Psychology, 48*(11), 643–648. https://doi.org/10.1111/jasp.12554

Postmes, T., & Spears, R. (1998). Deindividuation and antinormative behavior: A meta-analysis. *Psychological Bulletin, 123*(3), 238–259. https://doi.org/10.1037/0033-2909.123.3.238

Scheier, M. F. (1980). Effects of public and private self-consciousness on the public expression of personal beliefs. *Journal of Personality and Social Psychology, 39*(3), 514–521. https://doi.org/10.1037/0022-3514.39.3.514

Schultz, E. S., Gruzieva, O., Bellander, T., Bottai, M., Hallberg, J., Kull, I., Svartengren, M., Melén, E., & Pershagen, G. (2012). Traffic-related air pollution and lung function in children at 8 Years of age. *American Journal of Respiratory and Critical Care Medicine, 186*(12), 1286–1291. https://doi.org/10.1164/rccm.201206-1045OC

Schultz, P. W., Khazian, A. M., & Zaleski, A. C. (2008). Using normative social influence to promote conservation among hotel guests. *Social Influence, 3*(1), 4–23. https://doi.org/10.1080/15534510701755614

Shancita, I., Masjuki, H. H., Kalam, M. A., Rizwanul Fattah, I. M., Rashed, M. M., & Rashedul, H. K. (2014). A review on idling reduction strategies to improve fuel economy and reduce exhaust emissions of transport vehicles. *Energy Conversion and Management, 88*, 794–807. https://doi.org/10.1016/j.enconman.2014.09.036

Sharma, A., & Kumar, P. (2018). A review of factors surrounding the air pollution exposure to in-pram babies and mitigation strategies. *Environment International, 120*, 262–278. https://doi.org/10.1016/j.envint.2018.07.038

Sommet, N., & Morselli, D. (2017). Keep calm and learn multilevel logistic modeling: A simplified three-step procedure using stata, R, Mplus, and SPSS. *International Review of Social Psychology, 30*(1). https://doi.org/10.5334/irsp.90

Sparkman, G., & Walton, G. M. (2017). Dynamic norms promote sustainable behavior, even if it is counternormative. *Psychological Science, 28*(11), 1663–1674. https://doi.org/10.1177/0956797617719950

Täuber, S., van Zomeren, M., & Kutlaca, M. (2015). Should the moral core of climate issues be emphasized or downplayed in public discourse? Three ways to successfully manage the double-edged sword of moral communication. *Climatic Change, 130*(3), 453–464. https://doi.org/10.1007/s10584-014-1200-6

Van de Vyver, J., Abrams, D., Hopthrow, T., Purewal, K., de Moura, G. R., & Meleady, R. (2018). Motivating the selfish to stop idling: Self-interest cues can improve environmentally relevant driver behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour, 54*, 79–85. https://doi.org/10.1016/j.trf.2018.01.015

Weinmayr, G., Romeo, E., De Sario, M., Weiland, S. K., & Forastiere, F. (2010). Short-term effects of PM10 and NO2 on respiratory health among children with asthma or asthma-like symptoms: A systematic review and meta-analysis. *Environmental Health Perspectives, 118*(4), 449–457. https://doi.org/10.1289/ehp.0900844

Williams, D. M. (2010). Outcome expectancy and self-efficacy: Theoretical implications of an unresolved contradiction. *Personality and Social Psychology Review, 14*(4), 417–425. https://doi.org/10.1177/1088868310368802

Zeileis, A., & Hothorn, T. (2002). Diagnostic checking in regression relationships. *R News, 2*(3), 7–10. https://CRAN.R-project.org/doc/Rnews/.