Increasing Intention to Reduce Fossil Fuel Consumption: A Protection Motivation Theory Based
Experimental Study

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Abstract

Reducing individual fossil fuel use is an important component of climate change mitigation, but motivating behaviour change to achieve this is difficult. This experimental study tests the impact of Protection Motivation Theory based messages on intention to reduce fossil fuel use in 3803 US adults recruited via Amazon MTurk (mean age = 36.11 years; 51.4% female). Only messages targeting self-efficacy and response efficacy increased intention to reduce fossil fuel use relative to the control group. However, only the self-efficacy message had an impact on its corresponding construct, highlighting the importance of manipulation checks in model testing. Given the urgency of responding to climate change, the potential for additive benefits of effective messages should be considered irrespective of their underlying psychological mechanism. Study preregistration: <https://doi.org/10.17605/OSF.IO/2G6BQ>. Data related to this manuscript: <https://doi.org/10.17605/OSF.IO/2TRBK>.

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Anthropogenic climate change represents an existential threat to humanity (IPCC, 2018). Consumption of fossil fuels is among the most influential factors in climate change (Höök and Tang, 2013). Large-scale reductions in fossil fuel consumption could lead to substantial reductions in total greenhouse emissions (Dietz et al., 2009). Individual change will not meet emissions targets alone, but are an important response to climate change (Dietz et al., 2009). Unfortunately, individual fossil fuel consumption remains high (International Energy Agency, 2017). While structural barriers such as cost and feasibility influence use, investigating the psychological processes that underlie consumption may aid development of interventions to increase climate-friendly behaviours (Clayton et al., 2015). Theories of persuasive communication may provide one useful avenue for reducing this behaviour (Cismaru et al., 2011).

Protection Motivation theory

According to Protection Motivation Theory (PMT), behaviour is determined by the two parallel cognitive processes - coping appraisal and threat appraisal (see Figure 1; Rogers, 1975; Norman et al., 2015). Coping appraisal is determined by three constructs: response efficacy (perceived effectiveness of behaviour in averting a threat); self-efficacy (perceived ability to perform the behaviour); and response costs (perceived costs and barriers associated with behaviour adoption; Norman et al., 2015). Coping efficacy is maximised when response costs are low but response efficacy and self-efficacy are high. Threat appraisal is determined by three constructs: threat severity (perceived seriousness of the threat); susceptibility (perceived vulnerability to the threat); and maladaptive response rewards (perceived benefits of engaging in a maladaptive response such as avoidance or denial; Norman et al., 2015). Threat appraisal is

maximised when maladaptive response rewards are low but susceptibility and severity are high. Intention increases as a function of both threat and coping appraisals (Norman et al., 2015).

Figure 1. Protection Motivation Theory

Despite calls for experimental tests of psychological theory within environmental and conservation psychology (e.g. Kidd et al., 2019; Nelson et al., 2011), few studies have sought to test causal connections between PMT constructs and intention within this domain (Kothe et al., 2019). This is despite frequent recommendations for the use of PMT in designing pro-environmental campaigns (see Cismaru et al., 2011; Nelson et al., 2011; Scharks, 2016).

Previous work shows that PMT-based messages can be effective in changing beliefs (Floyd et al., 2000; Milne et al., 2000). By investigating messages that elicit change in different PMT constructs, researchers have identified messages most effective at increasing a given behaviour (e.g. Pechmann et al., 2003). However, as yet no studies have systematically

investigated the impact of messages targeting different PMT constructs within any pro-environmental behaviour.

The current study

We systematically investigated the impact of short messages that target PMT constructs on intention to reduce fossil fuel consumption. Each message targeted one PMT construct; the impact of each construct on intention and its target construct was examined.

Hypotheses

1. The primary outcome is intention to reduce fossil fuel consumption. It is hypothesised that intervention messages will increase intention relative to control.
2. The secondary outcomes are the PMT constructs. It is hypothesised that intervention messages targeting a given PMT construct will affect that construct relative to control.

Specifically, relative to control the:

- a. response cost message will decrease perceived response cost
- b. maladaptive response rewards message will decrease perceived maladaptive response rewards
- c. response efficacy message will increase perceived response efficacy
- d. severity message will increase perceived severity
- e. susceptibility message will increase perceived susceptibility
- f. self-efficacy message will increase self-efficacy

Methods

This study was pre-registered using the template developed by van't Veer and Giner-Sorolla (2016) <https://doi.org/10.17605/OSF.IO/2G6BQ>. Data related to this manuscript is available at <https://doi.org/10.17605/OSF.IO/2TRBK> under a CC-BY 4.0 license.

Participants

Participants were recruited via Amazon MTurk to take part in a study entitled “Short study of responses to messages about scientific issues” in exchange for \$1.10USD in Amazon credit. Sample size was determined *a priori*, we aimed to recruit a minimum of 526 participants per cell in order to detect an effect of $d = .2$, with 80% power and an alpha of 0.0083. To account for missingness, we oversampled each cell by 20, leading to a recruitment target of 546 per condition and a total recruitment target of 3822. After removal of duplicate and incomplete submissions, 3803 participants were included in this study.

Gender was manually categorised from free-text responses. Four responses could not be categorised (i.e. they did not appear to reflect gender identity: “%” or “40”). Three participants reported an age below the allowed age for registration on MTurk or above 200 years. For both gender and age, these problematic values were converted to missing but data were otherwise retained. One participant provided no demographic information. See Table 1 for a summary of participant characteristics.

Table 1. *Demographic characteristics of participants*

	Overall
n	3803
Age in years (mean (sd))	36.11 (11.57)
Highest level of education (%)	
Less than high school	13 (0.3)
High school diploma or GED	359 (9.4)
Some college	824 (21.7)
Associate's degree	475 (12.5)
Bachelor's degree	1551 (40.8)
Professional or Masters degree	510 (13.4)
Doctorate	70 (1.8)
Gender (%)	
Male	1837 (48.3)
Female	1956 (51.4)
Non-binary	5 (0.1)
NA	4 (0.1)
Annual household income (%)	
Less than \$10,000	165 (4.3)
\$10,000 - \$19,999	266 (7.0)
\$20,000 - \$29,999	426 (11.2)
\$30,000 - \$39,999	472 (12.4)
\$40,000 - \$49,999	436 (11.5)
\$50,000 - \$59,999	446 (11.7)
\$60,000 - \$69,999	309 (8.1)
\$70,000 - \$79,999	331 (8.7)
\$80,000 - \$89,999	205 (5.4)
\$90,000 - \$99,999	181 (4.8)
\$100,000 - \$149,999	348 (9.2)
More than \$150,000	151 (4.0)
Prefer not to say	66 (1.7)
Ideology - General (mean (sd))	4.38 (2.91)
Ideology - Economic (mean (sd))	4.81 (2.93)
Ideology - Social (mean (sd))	4.00 (3.08)

Procedure

Participants completed an online questionnaire that included all measures and the experimental manipulation via Qualtrics.

The first component of the questionnaire included demographic items. Participants were then randomly allocated (by Qualtrics) to one of the six intervention groups or a no message control group. Individuals allocated to receive an intervention message were shown a message related instruction and then the target message. Individuals in the control group did not receive the instruction or message and instead proceeded directly to the next part of the survey. Participants were not notified of their condition. In the third part of the questionnaire, participants completed the PMT questionnaire. The order of items within the PMT questionnaire was randomised to reduce order effects. At the conclusion of the study participants were invited to provide feedback on the survey via a free-text response box.

Data for this project was collected concurrently with data for a second project (described at <http://osf.io/87kwb>). Each participant took part in only one project. Although the projects were not intended to be analysed or reported together, their structural similarity could cause unexpected effects for participants who participated in both (e.g. unblinding). The intention to analyse and report the studies separately was documented in the pre-registration.

Messages

Participants were randomised to receive one of six intervention messages or to a no message control group. Each intervention message was designed to target a single PMT construct.

- *“We need to reduce our use of fossil fuels in order to reduce the risks of climate change. Reducing your fossil fuel dependence is easy. You can change your use of fossil fuels with lots of little steps by driving less or doing one big load of laundry rather than multiple small loads.” - Self-Efficacy*
- *“We need to reduce our use of fossil fuels in order to reduce the risks of climate change. Many households can save hundreds of dollars each year simply by installing more efficient lights. Small changes like this make a difference and allow you to save money and help the environment at the same time.” - Response Efficacy*
- *“We need to reduce our use of fossil fuels in order to reduce the risks of climate change. It doesn’t take a lot of time and effort to reduce your fossil fuel usage, you can do something as simple as changing your electricity supply to one using more renewable energy sources.” - Response Costs*
- *“The climate is changing. Climate change will lead to serious consequences in the United States including increased and more prolonged drought. Climate change is already contributing to water shortages around the globe.” - Severity*
- *“The climate is changing. These changes put everyone at risk. Whether or not you realize it, climate change is already affecting your life, by making extreme weather events more frequent and increasing food prices.” - Susceptibility*
- *“The climate is changing. Some people believe that climate change will lead to a more comfortable climate due to higher average daytime temperatures, but researchers agree that even in developed countries changes to our climate will disrupt basic necessities like food, clean air, and clean water.” - Maladaptive Response Rewards*

Measures

Demographics. Participants completed items regarding age, gender, education, household income, and political ideology. Political ideology was measured using three ideological self-placement items. Participants were asked to indicate “When it comes to ... would you consider yourself” with reference to “politics in general”, “economic issues” and “social issues”. Each item was measured on a 0-10 point scale (0 = “Very Liberal”; 10 = “Very Conservative”).

PMT measures. Each PMT construct was measured as the mean of three items (1 = Strongly Disagree, 5 = Strongly Agree). Intention was measured regarding the referent behaviour “reduce my use of fossil fuels from now on”. Higher self-efficacy scores indicate that individuals would be capable of reducing their use of fossil fuels ($\alpha = 0.71$). Higher response efficacy scores indicate participants’ belief that reducing their use of fossil fuels would be effective in reducing climate change ($\alpha = 0.82$). Higher response costs indicate the belief that there are costs (including non-financial costs) associated with reducing fossil fuels ($\alpha = 0.74$). Higher scores indicate greater intention to reduce fossil fuel consumption ($\alpha = 0.94$). Higher severity scores indicate the belief that the negative impact of climate change was severe ($\alpha = 0.85$). Higher susceptibility scores indicate greater perceived susceptibility to negative impacts of climate change ($\alpha = 0.83$). Higher maladaptive response rewards scores indicate the view there are benefits of doing nothing regarding climate change or to climate change occurring ($\alpha = 0.51$).

Data analysis

We used R (Version 3.5.1; R Core Team, 2018) and the R-packages *dplyr* (Version 0.8.3; Wickham et al., 2019), *knitr* (Version 1.24; Xie, 2015), *papaja* (Version 0.1.0.9842; Aust and Barth, 2018), and *psych* (Version 1.8.4; Revelle, 2018) for data cleaning, analyses, and

presentation. All t-tests were conducted using Welsch's t-test. The alpha for the study was $\alpha = 0.0083$.

Results

Pre-registered analyses

T-tests (see Table 2) examined the effect of each intervention message on intention relative to the control group. Messages designed to increase self-efficacy ($t(1,080.19) = -3.51$, $p < .001$) and response efficacy ($t(1,077.17) = -3.89$, $p < .001$) were effective, although other messages were not (Severity: $t(1,071.68) = 0.54$, $p = .588$; Susceptibility: $t(1,080.51) = -0.05$, $p = .961$; maladaptive response rewards: $t(1,083.00) = 0.59$, $p = .558$; Response Costs: $t(1,084.61) = -1.50$, $p = .134$).

Table 2. *Impact of interventions on intention to reduce fossil fuel consumption relative to control*

Comparisons	Control			Intervention			<i>t</i>	<i>p</i>
	Mean	SD	N	Mean	SD	n		
Control vs. Self-efficacy	3.41	1.06	540	3.64	1.03	544	-3.51	< .001
Control vs. Response Efficacy	3.41	1.06	540	3.66	1.01	543	-3.89	< .001
Control vs. Response Costs	3.41	1.06	540	3.51	1.06	547	-1.50	.134
Control vs. Severity	3.41	1.06	540	3.38	1.14	539	0.54	.588
Control vs. Susceptibility	3.41	1.06	540	3.42	1.09	543	-0.05	.961
Control vs. MRR	3.41	1.06	540	3.38	1.07	545	0.59	.558

Note. MRR = Maladaptive Response Rewards

Table 3. *Impact of interventions on target construct relative to control*

Comparisons	Construct	Control			Intervention			<i>t</i>	<i>p</i>
		Mean	SD	N	Mean	SD	n		
Control vs. Severity	Severity	3.88	1.01	541	3.85	1.07	539	0.55	.580
Control vs. Susceptibility	Susceptibility	3.72	1.04	540	3.81	0.97	543	-1.48	.138
Control vs. MRR	MRR	2.55	0.85	541	2.61	0.87	545	-1.07	.284
Control vs. Self-efficacy	Self-efficacy	3.05	0.90	541	3.50	0.89	544	-8.27	< .001
Control vs. Response Efficacy	Response Efficacy	3.31	1.03	540	3.43	1.07	543	-1.76	.078
Control vs. Response Costs	Response Costs	3.26	0.94	541	3.19	0.96	547	1.24	.216

Note. MRR = Maladaptive Response Rewards

T-tests also tested the impact of each message on the PMT construct it was designed to target (i.e. the effect of the *Self-Efficacy message* on *self-efficacy*) relative to Control. Only the Self-Efficacy message changed its target construct (see Table 3).

Exploratory analyses

An exploratory analysis was conducted to examine whether the Response Efficacy group differed from the Control group on any constructs other than response efficacy and intention. As shown in Table 4 the Response Efficacy group had significantly higher self-efficacy than the Control group and significantly lower perceived response costs.

Table 4. *Exploratory analysis: impact of response efficacy message on other constructs*

Construct	Control			Intervention			<i>t</i>	<i>p</i>
	Mean	SD	N	Mean	SD	n		
Severity	3.88	1.01	541	3.88	1.05	543	0.05	.959
Susceptibility	3.72	1.04	540	3.76	1.05	542	-0.56	.576
MRR	2.55	0.85	541	2.50	0.83	543	1.03	.304
Self-efficacy	3.05	0.90	541	3.48	0.84	543	-8.26	< .001
Response Costs	3.26	0.94	541	2.95	0.95	543	5.37	< .001

Note. MRR = Maladaptive Response Rewards

We tested a model where self-efficacy mediated the relationship between message type and intention. The difference in intention between those in the control and self-efficacy message conditions (c: $\beta = 0.22$, $t(1082) = 3.51$, $p < .001$) could be accounted for by differences in self-efficacy (condition – self efficacy: $\beta = 0.45$, $t(1083) = 8.27$, $p < .001$; self efficacy - intention: $\beta = 0.69$, $t(1082) = 24.05$, $p < .001$). After accounting for the indirect effect through self-efficacy,

the relationship between condition and intention was not significant (c' : $\beta = -0.09$, $t(1082) = -1.64$, $p = .101$).

Discussion

The aim of this study was to systematically investigate the impact of messages targeting PMT constructs on intention to reduce fossil fuel consumption. It was hypothesised these messages would increase intention to reduce fossil fuel use relative to control. Messages designed to increase self-efficacy and response efficacy were effective, although other messages that targeted severity, susceptibility, maladaptive response rewards and response costs were not. Exploratory analyses suggest that the self-efficacy message may have impacted intention by influencing self-efficacy. However, the response efficacy message did not increase response efficacy and instead appeared to influence self-efficacy and response costs. While effect sizes suggest that, relative to control, the response efficacy message had a larger impact on intention than the self-efficacy message [Cohen's $d_{\text{response efficacy}}$: 0.24; Cohen's $d_{\text{self-efficacy}}$: 0.22], this difference is small and given the differences in the apparent mechanisms of action should be interpreted with caution.

One previous study found no difference between individuals exposed to self-efficacy and control messages in intention to reduce carbon footprint, however, their results suggested a failure of the self-efficacy manipulation (Greenhalgh, 2011). As such, our results provide the first piece of experimental evidence of a causal relationship between self-efficacy, as conceptualised by PMT, and intention in the context of pro-environmental behaviour.

Two studies have sought to experimentally manipulate response efficacy. In one study (Ahern, 2008) the response efficacy message did not change response efficacy, and while Kantola et al. (1983) found their message induced change in response efficacy, it did not lead to increased intention to conserve water. In our sample, the response efficacy group had higher average intention to reduce fossil fuel consumption than the control group, however, this was not accompanied by differences in response efficacy itself. Taken together with the previous studies (Ahern, 2008; Kantola et al., 1983), this suggests there is limited evidence for changes in response efficacy leading to changes in intention within the context of pro-environmental behaviour.

Messages targeting response costs, severity, susceptibility, and maladaptive response rewards also did not lead to changes in intention or in their target constructs. This is the first study to attempt to experimentally manipulate maladaptive response rewards or response costs (Kothe et al., 2019), and previous attempts to experimentally manipulate severity and susceptibility in order to bring about changes in intention have had limited success. While Huth et al. (2018) reported an effect of a severity manipulation on purchasing intention, Chen (2016) found that individuals in their “high threat” condition actually reported lower evoked fear than their “low threat” condition in the context of an intervention that simultaneously targeted susceptibility and severity, while Kantola et al. (1983) found that a message that was successful in increasing severity had no impact on intention. As a result, evidence for a causal relationship between threat appraisal constructs from the PMT and intentions to engage in pro-environmental behaviours is currently very limited. The design of messages that effectively alter these PMT constructs is a necessary precondition for evaluating causality and as such should be a focus of future research.

As this study demonstrates, even when messages are effective in increasing intention, it cannot be assumed to be a function of change in the target construct (c.f. Chen, 2016).

Manipulation checks are often not conducted or reported within the PMT pro-environmental literature (Kothe et al., 2019), or in experimental papers based on similar theoretical approaches (e.g. Hardeman et al., 2002). These results highlight the importance of such manipulation checks to theory testing, particularly as the conceptual similarity between PMT constructs may make the creation of messages that target just one PMT construct difficult. However, this is only a problem within the context of theory development and testing, not for tests of effectiveness. Given the urgency of addressing climate change, identifying these causal mechanisms may be of limited importance when presented with an approach to changing intentions or behaviour that appears to be effective.

Conclusion

Overall, the results of this study suggest that efficacy based messages can be effective at increasing intention to reduce fossil fuel consumption. However, as the effects were only evaluated immediately post message presentation, the extent to which these effects can be maintained over time requires further examination as does the extent to which the effects result in subsequent increases in engagement in actual pro-environmental behaviours. Further, given that the effects are small and would reasonably be expected to diminish over time, it may be useful to consider whether efficacy messages could be combined to increase their impact.

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