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Do effects of theoretical training and rewards for energy-efficient behavior persist over time and interact? A natural field experiment on eco-driving in a company fleet

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HIGHLIGHTS

- Natural field experiment on training and incentives for fuel-efficient driving.
- Focus on long-term and interaction effects over twelve months.
- Immediate reduction effect of non-monetary reward that attenuates over time.
- Theoretical eco-driving training shows no effect, neither short-term nor long-term.
- Interaction of incentives and training shows no additional reduction effect.

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ABSTRACT

Increasing energy efficiency is a cornerstone of policy initiatives to tackle climate change and increase corporate sustainability. Convincing people to drive more fuel-efficiently ("eco-driving") is often an integral part of these approaches, especially in the transport sector. But there is a lack of studies on the long-term persistence and potential interaction of the effects of incentives and training on energy conservation behavior in general and eco-driving behavior in particular. We address this gap with a twelve months long natural field experiment in a logistics company to analyze the time-dependent and potentially interacting effects of rewards and theoretical training for eco-driving on fuel consumption in a real-world setting. We find an immediate reduction of fuel consumption following the introduction of a non-monetary reward and an attenuation of this effect over time. Theoretical eco-driving training shows no effect, neither short-term nor long-term, highlighting the often neglected necessity to include practical training elements. Contrary to common assumptions, the interaction of incentives and theoretical training does not show an additional reduction effect. Our results demonstrate the difficulty of changing engrained behavior and habits, and underline the need for a careful selection and combination of interventions. Policy implications for public and private actors are discussed.

1. Introduction

Facing the impending consequences of climate change, governments around the world try to implement effective policies to reduce greenhouse gas emissions. At the same time, also the private sector increases its efforts to cut down energy costs and increase industrial sustainability. As the source of 17% of the world's total energy-related CO2 emissions (IPCC, 2014), the road transport sector is an essential domain for analyzing energy consumption behavior. Besides a broad range of external influences, the driving style has a large impact on the fuel consumption (Anable and Bristow, 2007; McKinnon, 2008). With fuel-efficient driving ("eco-driving") a reduction of the fuel consumption typically between 5% and 25% is possible (Daun et al., 2013; Santos et al., 2010; Symmons et al., 2008).

Previous studies on energy-efficient behavior and fuel-efficient driving behavior have already looked at many different types of interventions such as, e.g., transparency, information, decision-support mechanisms, training, and social comparison (for an overview see Abrahamse et al., 2005; Santos et al., 2010). But we still observe gaps in the existing research:

First, many studies as well as training providers state that eco-

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driving training reduces fuel consumption (af Wåhlberg and Göthe, 2007; Austrian Energy Agency, 2013; Beusen et al., 2009; Cebrat, 2010; Haworth and Symmons, 2001; Reinhardt, 2001; Symmons et al., 2008), but they do not seem to differentiate at all or at least not enough between different types of training (with the notable exception of Symmons et al., 2009).

Second, studies on energy conservation mostly look at short-term effects of behavioral interventions. But there is a lack of studies that analyze the effects over a time period longer than a few weeks or months, especially in the case of eco-driving training (af Wåhlberg, 2007; af Wåhlberg and Göthe, 2007; Beusen et al., 2009; Daun et al., 2013). The variation of the impact of interventions on energy conservation behavior over time is still largely unknown (Allcott and Rogers, 2014). In particular, the long-term effectiveness of reward schemes to change travel behavior and the effect of financial incentives on energy conservation behavior over time are still unclear (Dolan and Metcalfe, 2013; Khademi and Timmermans, 2014).

Third, the existing research often recommends a combination of different measures as the optimal policy choice for proenvironmental behavior (Bonsall et al., 2009; Gardner and Stern, 2002; Stern, 2000), e.g. a combination of knowledge-increasing measures such as training and economic incentives to stimulate eco-driving (Barkenbus, 2010; Cloke et al., 1999). However, these studies typically show a lack in investigating the individual and the interacting effects of such a combination of measures.

We address these gaps with a natural field experiment on the effects of rewards and training for eco-driving on fuel consumption over time. Metcalfe and Dolan (2012) describe a need within transport to conduct field experiments in behavior but "cannot find any studies within transport that have used natural field experiments to demonstrate causality" (Metcalfe and Dolan, 2012, p. 508). Thus, this study is arguably the first natural field experiment within transport research to demonstrate causality. First, we introduced a monetary and a non-monetary reward for eco-driving, an intervention rarely studied before in transport research, to drivers of light commercial vehicles in different branches of a German logistics company and tested their efficacy, i.e., if they lead to reduced fuel consumption, over a period of twelve months. In addition, because preliminary results after a few months indicated that the drivers did not fully realize their eco-driving potential, after six months a group of drivers took part in an eco-driving training to evaluate if this additional measure induces a higher level of eco-driving. To our knowledge, this is the first study that analyzes empirically the time-dependent and potentially interacting effects of incentives and training for eco-driving on fuel consumption in a real-world setting. The results indicate that incentives for eco-driving can work in the short and middle run, but purely theoretical training and interacting incentives with such training might not be effective measures to "nudge" people into the desired proenvironmental direction.

The remainder of this paper is organized as follows: we give an overview of the current state of research on incentives and training for eco-driving in Section 2. We introduce the experimental design and procedure in Section 3 and present the results in Section 4. Finally, we discuss our results as well as the limitations of our study in Section 5 and conclude the paper in Section 6 with the implications and suggestions for future research.

2. Incentives and training for eco-driving

2.1. Eco-driving

The main characteristics of a fuel-efficient and thus economically and ecologically beneficial driving style, often called "eco-driving" (Santos et al., 2010), can be summarized as follows (Barkenbus, 2010; Cloke et al., 1999): (1) Accelerating moderately and changing gear optimally, (2) keeping a safe distance from other vehicles and anticipating traffic flow and signals to avoid unnecessarily sharp breaking and acceleration, (3) driving at appropriate speeds and maintaining an even driving pace, and (4) avoiding excessive idling.

Driving speed and aggressiveness, i.e., abrupt and high acceleration and heavy breaking/deceleration (Ericsson, 2001), seem to be the main factors that determine the level of fuel consumption (Barth and Boriboonsomsin, 2009; Berry, 2010; Cloke et al., 1999). Driving at (or closer to) the optimum speed in terms of fuel consumption, typically between 60–80 km/h, could save up to 10% of fuel (An et al. as cited in Cloke et al., 1999; Haworth and Symmons 2001). A less aggressive driving style, i.e., moderate acceleration and earlier gear changes, may also save around 10% of fuel (An et al. as cited in Cloke et al., 1999). Based on a real-world driving set, Berry (2010) found that reducing speed during highway driving saves about as much fuel as reducing accelerations during all driving (a 20% reduction in either category would result in 5% less overall fuel consumption of a Ford Focus). Maintaining an even driving pace and anticipating stops could reduce fuel consumption by 8% (An et al. as cited in Cloke et al., 1999). Avoiding idling, for example with an idle start-stop system, can reduce fuel consumption between 4% and 10% (Fonseca et al., 2011; Natural Resources Canada, 2016). While the exact saving potential depends on the specific circumstances, e.g., car type, route, and benchmark, previous studies typically found that eco-driving can reduce the overall fuel consumption of passenger vehicles and light commercial vehicles between 5% and 25% (Daun et al., 2013; Santos et al., 2010; Symmons et al., 2008; van der Voort et al., 2001).

2.2. Combining incentives and training for eco-driving

The existing research often underlines the limits of single-instrument policies and recommends a combination of different measures as optimal policy choice for pro-environmental behavior (Bonsall et al., 2009; Gardner and Stern, 2002; Stern, 2000). There is evidence that incentives and information interact, with the combination of both sometimes being more effective than the sum of the two interventions (Stern, 1999, 2000).

The effect of training alone on driving style might be limited because it equips drivers with the necessary knowledge (theoretical training) and skills (practical training) to drive more fuel-efficiently, but it does not necessarily change their choice of how to drive (Cloke et al., 1999). Training might be necessary but not sufficient to realize the full eco-driving potential. Thus, a combination of knowledge-increasing measures such as training and economic incentives to stimulate eco-driving might result in stronger eco-driving and higher fuel-efficiency (Barkenbus, 2010; Cloke et al., 1999). We follow this approach and hypothesize:

Hypothesis 1. The interaction of eco-driving training and economic incentives for eco-driving has a reduction effect on fuel consumption.

However, related research points in a different direction. Introducing two interventions at the same time is a strong extrinsic interference that can lead to a crowding out effect, i.e., a reduction or even elimination of intrinsic motivation in this case (Deci and Ryan, 1985; Dzuranin and Stuart, 2012). In addition, Dolan and Metcalfe (2013), for example, even found a reduction of a financial incentive's strength if it is interacted with social norm information and suggest that social norms reduce the extrinsic motivational power of financial incentives to reduce energy consumption. Furthermore, previous research does not allow a conclusion as to