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The effect of 'smart' financial incentives on driving behaviour of novice drivers

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ABSTRACT

Recent studies have demonstrated that financial incentives can improve driving behaviour but high-value incentives are unlikely to be cost-effective and attempts to amplify the impact of low-value incentives have so far proven disappointing. The present study provides experimental evidence to inform the design of 'smart' and potentially more cost-effective incentives for safe driving in novice drivers. Study participants (n = 78) were randomised to one of four financial incentives: high-value penalty; low-value penalty; high-value reward; low-value reward; allowing us to compare high-value versus low-value incentives, penalties versus rewards, and to test specific hypotheses regarding motivational crowding out and gain/loss asymmetry. Results suggest that (i) penalties may be more effective than rewards of equal value, (ii) even low-value incentives can deliver net reductions in risky driving behaviours and, (iii) increasing the dollar-value of incentives may not increase their effectiveness. These design principles are currently being used to optimise the design of financial incentives embedded within PAYD insurance, with their impact on the driving behaviour of novice drivers to be evaluated in on-road trials.

1. Introduction

Despite significant improvements in road safety, road injuries remain the ninth highest cause of burden of disease and are responsible for more than 100,000 deaths per year across high-income countries such as Australia, Japan and the United States (IHME, 2016). For high-income countries, year-on-year improvements in road safety have become increasingly marginal (IHME, 2016) and achieving further reductions in road trauma will require design and scaled delivery of novel road safety measures (Stevenson and Thompson, 2014).

The advent of in-vehicle telematics with GPS-tracking has made possible the accurate and continuous monitoring of risky driving behaviours including distance travelled, speeding, hard acceleration/deceleration, and night-time driving (Horrey et al., 2012). While this technology is now mature (Chang and Fan, 2016) and has found application for monitoring driving behaviour in commercial fleets and pay-as-you-drive (PAYD) insurance for private vehicles (Greaves and Fifer, 2011; NCTCG, 2008), there remains an opportunity for improvements and for delivery-at-scale of road-safety measures designed around in-vehicle telematics systems (Stevenson and Thompson, 2014). These opportunities include linking trip data from in-vehicle telematics with other 'big data' to predict crash risk (McLaughlin and Hankey, 2015), real-time in-vehicle alerts and/or automated throttle control via intelligent speed adaptation systems (e.g. Reagan et al., 2013), delayed or immediate feedback via a smart-phone or web-interface (e.g. Dijksterhuis et al., 2015), and financial incentives that reward good driving behaviours and/or impose penalties for risky driving behaviours (e.g. Bolderdijk et al., 2011).

The evidence regarding the effectiveness of incentives for safe driving has historically been limited to the impact of speed cameras, drink-driving legislation and the associated risks of financial penalty (Avineri et al., 2010). Recent studies have evaluated the impact of direct incentives for safe driving including exchangeable tokens plus feedback for safe on-road driving (Mazureck and van Hattem, 2006), exchangeable tokens plus/minus feedback for decreased speeding in simulated driving scenarios (Mullen et al., 2015), financial incentives plus/minus feedback for reductions in on-road speeding (Reagan et al., 2013), and the effect of behaviour-based and mileage-based PAYD

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vehicle insurance (or similarly structured incentives) on on-road driving behaviour (Agerholm et al., 2008; Bolderdijk et al., 2011; Bolderdijk and Steg, 2011; Greaves and Fifer, 2011; Lahrmann et al., 2012; NCTCG, 2008) and in simulated driving scenarios (Dijksterhuis et al., 2015).

Early trials of PAYD incentives offered large monetary rewards in return for changes in driving behaviour (Bolderdijk and Steg, 2011; Greaves and Fifer, 2011). For example, one study offered up to €50 per month for keeping to the speed limit, reductions in distance travelled and reductions in weekend night-time driving; resulting in significant reductions in the percentage of total distance travelled at ≥6% above the local speed limit (Bolderdijk and Steg, 2011). While this suggests that financial incentives can influence driving behaviour, the large monetary rewards used in these studies "may not be economically feasible for insurance companies" (Bolderdijk and Steg, 2011 p18); leading some stakeholders to call for the design of 'smarter' incentives that could achieve similar shifts in behaviour but at a much lower cost.

Recent studies have demonstrated that low-value incentives can be effective when combined with feedback but attempts to amplify the effects of these low-value incentives have proven disappointing (Dijksterhuis et al., 2015). Specifically, Dijksterhuis et al. (2015) combined low-value PAYD incentives (capped at €3 per simulator run) and in-car feedback (providing a running total of rewards and penalties during simulator runs) with the aim of increasing the immediacy of financial consequences arising from participants' driving behaviour. While the combination of feedback and low-value PAYD incentives produced significant improvements in driving behaviour when compared to untreated controls, varying the immediacy of feedback made little difference (€0.01/minute difference in payoffs between immediate and delayed feedback groups after feedback, equating to a €0.26 difference in payoffs for an average simulator run). Dijksterhuis et al. (2015) concluded that efforts to improve the effectiveness of PAYD incentives may yet prove fruitful but that these efforts should now turn to factors other than the immediacy of feedback (such as certainty of feedback).

More generally, designing 'smart' and potentially more cost-effective incentives may be difficult to achieve in practice. Evidence from behavioural economics suggests that offering a low-value reward can have the perverse effect (contrary to that which was intended) of reducing the desired behaviour (Frey and Oberholzer-Gee, 1997; Mellstrom and Johannesson, 2008). Specifically, there is a risk that an individual's intrinsic motivation for safe driving will be 'crowded out' (eroded or displaced) by extrinsic sources of motivation such as monetary rewards. A number of explanations for this 'motivational crowding-out' have been suggested in the literature including information communicated by incentives and the reputational consequences of accepting payment. For example, Gneezy et al. (2011) suggests that motivational crowding-out may be linked to the informational content of the reward; where an offer of monetary rewards could be interpreted as a signal that safe driving is difficult or unpleasant and so has to be paid for, or where the magnitude of the reward indicates the (unexpectedly low) social value of the behaviour. Alternatively, motivational crowding-out may be linked to the reputational value that an individual receives from adopting the target behaviour. When monetary rewards are present, drivers who would otherwise strive to maintain a reputation for safe driving as a signal of their concern for others, or of their community mindedness, can no longer distinguish themselves from drivers who adopt safe driving behaviours for more selfish reasons (i.e. payment). Put simply, intrinsically motivated 'safe drivers' may be less motivated to maintain the incentivised behaviour if safe driving carries no reputational value or – worse still – carries the implication that a 'safe driver' is 'in it for the money'. Motivational crowding out is likely to be much more problematic for low-value rewards simply because low-value rewards may be too small to compensate for any loss of intrinsic motivation (Culyer, 1971; Mellstrom and Johannesson, 2008; Titmuss, 1970).

It should be emphasised that the potential for motivational crowding out does not mean that monetary rewards cannot work. For individuals with low or no intrinsic motivation for safe driving, even very low-value rewards may still be effective because "…a crowding-out effect cannot occur… (where) participants have no intrinsic motivation to begin with" (Frey and Jegen, 2001 p597). For individuals with a stronger intrinsic motivation for safe driving, designing 'smart' incentives requires further information regarding the dollar-value that would be required to compensate for any loss of intrinsic motivation. Several studies provide empirical support for the effectiveness of monetary rewards in situations where participation or effort is subject to motivational crowding out, but only if the dollar-value is above the threshold where intrinsic motivation has been completely crowded-out (Gneezy and Rustichini, 2000; Heyman and Ariely, 2004).

Just as further information regarding the presence and extent of motivational crowding-out should assist in fine-tuning financial incentives, there may be scope to vary other features of an incentive to improve cost-effectiveness. Of particular relevance for the present study, incentives may be more effective when they exploit loss aversion and gain/loss asymmetry (Kahneman and Tversky, 1979). Loss aversion and gain/loss asymmetry are pervasive characteristics of preferences (Knetsch and Wong, 2009), with ratios of willingness to accept (WTA) to willingness to pay (WTP) well in excess of unity for private goods such as mugs, chocolate or hockey tickets and for public goods like environmental amenity or public infrastructure (Bischoff, 2008). Gain/loss asymmetry would imply that loss of a discount or upfront payment will have a much larger impact on driving behaviour than a reward or bonus of the same dollar value; with clear implications for the design of 'smarter' incentives. Previous tests of gain/loss asymmetry in PAYD schemes with large monetary rewards (up to €50 per month) found no significant difference between gain and loss frames (Bolderdijk et al., 2011).

This study provides empirical evidence to inform the design of 'smart' and potentially more cost-effective incentives for safe driving in novice drivers. Specifically, the study was designed to evaluate the practical significance of motivational crowding out when offering low-value financial incentives for safe driving, and the extent to which gain/loss asymmetry may be exploited to amplify the effectiveness of low-value financial incentives.

2. Materials & methods

2.1. Study design & hypotheses

An experimental design was applied to estimate the effect of (i) financial incentives versus no financial incentive, (ii) higher-value versus lower-value financial incentives, and (iii) penalties versus rewards, on risky driving behaviours among novice drivers in a simulated environment. Here, the term penalties is used to refer to the loss of an upfront payment deposited into a 'safe driving account' (see Table 1). Participants' driving behaviours (including exceeding the posted speed limit, hard braking and excessive swerving) were observed in simulated driving scenarios designed to replicate the experience of driving on local roads under local conditions.

To identify the effect of financial incentives versus no financial incentive, the experiment included a pre/post contrast wherein we observed participants' driving behaviour at baseline under the 'no incentive' condition (baseline simulator run) and then at follow-up under the 'financial incentive' conditions (experimental simulator run). Drivers were randomised to one of four financial incentives: high-value penalty (HP); low-value penalty (LP); high-value reward (HR); low-value reward (LR); allowing us to compare high-value versus low-value incentives, penalties versus rewards and to test specific hypotheses regarding motivational crowding out and gain/loss asymmetry.

To test for motivational crowding-out, we evaluated whether providing financial incentives had the perverse effect of increasing the