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Pay-as-you-drive vehicle insurance as a tool to reduce crash risk:

Results so far and further potential

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ABSTRACT

In this paper, we provide an extensive summary of a field experiment we have recently conducted on the behavioural effects of pay-as-you-drive (PAYD) vehicle insurance (Bolderdijk et al., 2011a). We start with a review of the rationale for PAYD schemes from a behavioural science perspective. Next, we describe the design of our study, and discuss and elaborate on the main empirical findings. Based on this, we present practical guidelines for policy makers and insurance companies aiming to introduce PAYD schemes as a tool to reduce crash risk, improve traffic safety, and reduce the negative environmental impacts of car use.

1 BEHAVIORAL DETERMINANTS OF CRASH RISK

Vehicle speed is commonly seen as the most important determinant of crash risk (Salusjärvi, 1981), and crash severity (Joksch, 1993; OECD/ECMT, 2006). Driving at higher speeds leaves less time to respond to unexpected events and increases stopping time, thus decreasing the possibility to avoid accidents (Aarts & van Schagen, 2006). So, reducing the travelling speed of drivers, and in particular the amount of time spent speeding, holds the potential of dramatically reducing accidents, and saving lives.

How can drivers be persuaded to reduce speeding? To answer this question, we first need to address the question why people take risks in the first place. According to applied behaviour analysis, all behaviour is determined by its consequences (Skinner, 1974, in Geller, 2005). People are motivated to do things for the promise of what follows. In other words, we do what we do to obtain positive consequences (e.g., speeding is perceived to save time, and may provide sensation seekers a sense of positive affect) or to escape or avoid negative consequences (e.g., speeding may prevent one from feeling bored).

Consequences are extremely important for explaining risky behaviours, like speeding, because these behaviours are typically followed by soon and certain positive consequences (rewards), while the negative consequences (penalties) are generally uncertain and not very likely at the short term. Indeed, and luckily, crashes due to speeding are relatively rare events and only a small percentage of total speed violations are fined. So, speeding often goes unpunished. Driving safely, conversely, offers little reward to the individual driver. Because of this specific alignment of consequences, speeding is a highly common phenomenon, proving hard to curtail (Fuller, 1991).

The solution to this problem, in principle, is thus straightforward: in order to change behavior, one needs to alter the consequences. Safe behaviors should be rewarded and risky behaviors penalized. In this paper, we discuss a new way to present such consequences, namely by implementing Pay-as-you-drive vehicle insurance.

Pay-as-you-drive vehicle insurance (PAYD hereafter) is a new type of car insurance that ties the level of insurance premium to the risk level associated with driving behavior of the policyholder. It thereby allows the direct administration of penalties for risky (e.g., speeding, driving during dangerous hours) behaviors and rewards for safe behaviors (e.g., keeping the speed limit). As such, it offers insurance companies a promising instrument for promoting driving at safe speeds and discouraging excessive speed violations, thus curtailing crash risk¹. We have recently conducted a field experiment to

¹ Note that insurance companies that utilize bonus/malus systems already offer rewards and penalties. Drivers who drive safely and consequently avoid having to file insurance claims are awarded no-claim discount on their insurance fee. This discount is revoked when a new claim is made. This practice seems to motivate safe driving behavior (Vaaje, 1991). Recently however, in an attempt to seduce customers and increase market share, some Dutch insurance companies have introduced so-called 'no-claim protectors'. Within this new scheme drivers can, for a small additional fee, buy the 'right' to keep their no-claim discount when they file a new claim. Although attractive for customers, from an applied behavioral perspective, this practice is highly inadvisable; it destroys an effective incentive for drivers to drive safely.

test whether PAYD can aid in reducing speed violations of young adults. To our knowledge, that study was the first to test the effects of PAYD on speeding, driving volume and nighttime driving in a randomized controlled field trial. This specific research designed allowed us to distinguish the effects of PAYD from extraneous factors, such as weather conditions and thus draw strong conclusions regarding the potential effects.

The next section describes the background and results of this field study; a more detailed discussion of this work can be found in Bolderdijk, Knockaert, Steg & Verhoef (2011a). Before reviewing the results of our field experiment, we will discuss the (dis-)advantages of Pay-As-You-Drive Vehicle Insurance as compared to current road safety interventions. Next, we discuss the scope of PAYD as a tool to promote safe driving behavior, as well as present recommendations for policy makers who aim to adopt PAYD schemes, relying on insights from psychological research.

2 PAY-AS-YOU-DRIVE VEHICLE INSURANCE: THE IDEA

2.1 Current road safety interventions: speed enforcement tools

Traditional road safety interventions, such as the obligatory use of safety belts, improved road design, and wider road lanes have had great success in lowering road deaths. However, there has been some argument that these measures have largely only reduced accident severity and have done little to address the human component of traffic accidents (Rothengatter, 2002). In particular, it is thought that some drivers, in response to the perceived safety gains of certain interventions, drive in a fashion that may reduce the potential safety gains created by the intervention (Wilde, 1986; Jackson & Blackman, 1994; Lewis-Evans & Charlton, 2006).

Contemporary speed enforcement tools (such as mobile radars) offer financial consequences for driving behavior and have been argued to more likely provide a net safety benefit, as they lower drivers' target level of risk (Wilde & Murdoch, 1982). Financial consequences, both negative (penalties) and positive (rewards) can provide additional financial costs to risky and financial benefits to cautious behavioral options, and thus may decrease drivers' target level of risk.

Such enforcement tools impose penalties (fines) on risky behavior (rather than providing rewards for safe behavior). Research shows that interventions involving penalties (e.g., mobile radars and fixed cameras providing fines to speed violators) indeed can effectively deter speeding in the general population (e.g., Goldenbeld & van Schagen, 2005; Shin et al., 2009), and thus reduce road crashes. Unfortunately, the deterring effects of such interventions are often only local, in that speeding is only reduced in the proximity of areas where driving speed is being monitored (Hauer et al., 1982). So, enforcement tools can only fine a small percentage of total speed violations committed.

Advanced speed monitoring systems provide the possibility for monitoring driving behavior constantly, across all roads, allowing financial penalties to be imposed on all, rather than just a subset of speed violations (OECD/ECMT, 2006). For example, GPS technology, combined with information on local speed limits, allows for the automatic and continuous monitoring of vehicle speed and by comparing current vehicle speeds with

local speed limits, one can establish whether and where speed violations occurred. Automatically detected violations could then be translated into financial penalties to drivers.

Such a system is potentially very effective in reducing overall speeding; it imposes consistent penalties on risky behavior. However, advanced speed monitoring systems do have one particularly large drawback preventing their implementation. That is, they are hardly acceptable to the general public, as people are likely to oppose a mandatory GPS device in cars that penalizes them for every speed violation they commit (OECD/ECMT, 2006). A recent development in the commercial sector, Pay-As-You-Drive vehicle insurance, may tackle this problem in an effective, yet acceptable way.

2.2 Pay-As-You-Drive vehicle insurance

PAYD entails that insurance premiums are directly based on the driving behavior of policyholders (Litman, 2005). Generally, PAYD ties the level of insurance premium to the risk level associated with driving behavior of the policyholder. For example, increased mileage and speeding are associated with increased crash risks, and thus can be used to determine the level of the insurance premium. This system of variable premiums poses an alternative to the current system of fixed insurance premiums that are exclusively based on proxies for risk such as age and gender, rather than on the actual driving behavior of policyholders. In addition to increasing actuarial accuracy (risks are better reflected in premium, cf. Litman, 2005), PAYD might lead to a change in the driving behavior of policyholders.

Because risk taking is reflected in individual insurance premiums, the system provides additional financial consequences associated with cautious and risky driving, in that by changing their driving behavior, policyholders can save money on their insurance. PAYD, particularly in combination with GPS devices in policy holders' cars, allows for the variabilisation of insurance premiums based on a multitude of risk factors, including driving volume (mileage) and driving style (e.g., speed, acceleration, deceleration), as well as other factors (e.g., time of driving).

As a tool for behavior change, PAYD may help in tackling major road-safety risks, such as speed violations and nighttime driving (Sivak et al., 2007), and may yield additional societal benefits through reduced mileage and smoother and more fuel efficient driving styles, such as lower vehicle emissions and reduced congestion. PAYD might be especially effective in changing the driving behavior of young drivers, who are typically overrepresented in accident statistics. This group traditionally pays relatively high premiums, and variabilisation of their premiums could therefore lead to relatively large financial incentives.

As a tool for reducing speed, PAYD (in combination with GPS technology) offers a number of advantages over more conventional speed enforcement tools. Since PAYD means that premiums are directly tied to actual driving behaviour (logged vehicle speeds), policyholders face a continuous and non-randomized financial incentive to keep the speed limit. Thus, as opposed to conventional speed enforcement tools, reduced speeding would not be limited to specific locations. Additionally, the perceived risk of detection, which is commonly seen as the crucial factor in speed enforcement (see De Waard & Rooijers, 1994) is very high with GPS-based monitoring, as all speed violations can have financial consequences.

Moreover, PAYD can be used to provide financial rewards (reduced premium) for cautious behavior (keeping the speed limit), besides imposing financial penalties for risky behavior. People generally rate rewards as more acceptable tools for behavior change than penalties (Wit & Wilke, 1990), which suggest that PAYD will probably be rated as more acceptable than advanced speed monitoring systems that typically only involve penalties (OECD/ECMT, 2006).

In the next section, we discuss the setup and statistical analyses of the field experiment we conducted on PAYD. A more detailed description can be found in Bolderdijk, Knockaert, Steg & Verhoef (2011).

3 PAY-AS-YOU-DRIVE VEHICLE INSURANCE: BEHAVIORAL EFFECTS

In a field experiment, we examined how PAYD, in combination with in-car GPS devices, affects driving behavior in a randomized controlled field trial. Specifically, we aimed to test to what extent a financial incentive (a reward in the form of a discount on policyholders' insurance premium) affects the actual driving speed of young drivers. Note that PAYD thus differs from current enforcement tools: it can offer rewards, and need not include penalties.

Literature suggests that speed is one of the most important predictors of crash risk (Aarts & van Schagen, 2006), therefore our primary interest was testing the effects of PAYD on speeding, which is driving above the posted speed limits. However, the field experiment also included a financial incentive for participants to reduce their mileage and avoid driving on weekend nighttime hours, as increased mileage and driving at night during weekends have been associated with increased accident risk (Sivak et al., 2007) as well.

3.1 Participants

In January 2007, we sent a letter with the request to fill out an online questionnaire on PAYD (duration 20 minutes) to approximately 6000 policyholders from five Dutch insurance companies (all policyholders were younger than 30 years). In the last part of the questionnaire, participants indicated whether they were interested in participating in a field experiment on PAYD. A substantial proportion of the people who filled out the questionnaire (228) were eventually invited to participate in the field experiment.

By the end of the experiment (July 2008), we could establish the prevalence of speeding behavior throughout all phases of the experiment for 141 participants. Self-reported mean yearly mileage of the final set of participants was 13,985 kilometers, which was comparable to the 2007 Dutch average of 13,877 kilometers (CBS, 2009). Men (60%) were slightly overrepresented in the sample.

3.2 Design and procedure

The field experiment ran from November 2007 until June 2008. Prior to the start of the field experiment, participants' cars were equipped with GPS devices. These GPS devices allowed for the monitoring of where participants were driving, what speed they were

driving at, at what time they were driving, and how many kilometers they were travelling.

Participants were randomly assigned to be either in incentive or control groups. The experiment comprised four phases, pre-measurement, intervention phase 1, intervention phase 2, and post-measurement, each lasting two months. During pre-measurement (November – December 2007) and post-measurement (May – June 2008), participants' driving behavior was monitored, but had no financial consequences.

During the intervention phases, participants in the incentive group could earn a reward for adapting their driving behavior (a discount on their insurance premium of maximally 50 Euro per month), and received feedback on their driving behavior via a custom webpage. Participants in the control group did not receive an incentive and feedback. They were told they would receive 200 euros by the end of the experiment, *regardless* of their driving behavior. The monthly 50 Euros discount was divided into three components: 30 Euros was designated as a reward for keeping the speed limit, 15 Euros for reduced mileage, and 5 Euros for avoiding driving during weekend nighttime hours. So, the maximum discount participants could earn during the two intervention phases was 200 Euro.

We reasoned that the effect of the monetary incentive would be maximized when combining it with feedback. Participants in the incentive groups could track their performance during the intervention phases (from January-April 2008) by logging in to a personalized website (www.savedriver.nl). The website provided detailed feedback on speed violations, mileage, and nighttime driving, and showed, by default, how much discount the particular participant would receive or forfeit at the end of the month if they continued the driving behavior of the previous week (See figure below).



Figure 1 Screenshot of feedback page

3.3 Data analysis

During the field experiment, in-vehicle GPS devices logged X and Y coordinates every 100 meters. The occurrence of speed violations was established by matching vehicle location and vehicle speed to a map with local speed limits.

The percentage of total distance travelled at 6% or more above the local speed limit ('percentage of speeding') was used as the main dependent variable in our analyses. Violations of less than 6% were excluded from this definition, based on the assumption that such violations are often non-volitional and therefore most likely not influenced by a financial incentive and feedback².

For each of the four phases of the field experiment, the percentage of speeding was calculated based on the weekly distance travelled at a speed 6% over the speed limit across all five road types (30, 50, 80, 100 and 120 km/h). Percentage speeding of the five road types were weighted by distance, and averaged across road types. The resulting variable represents an indicator of volitional speeding across all road types, and was used as a dependent variable in our analysis of the effect of PAYD on overall speeding.

Averaged over all participants and all phases, local speed limits were violated by 6% or more for 19.1% of the distance travelled during off-peak hours. This figure is in line with previous literature that used GPS devices to measure vehicle speeds (Hultkrantz & Lindberg, 2003). Because the variable percentage of speeding was not normally distributed the natural logarithm of the scores was used in the analyses.

² Many Dutch roads tend to be congested around peak hours on weekdays, and during congestion, participants' would have to deal with other vehicles ahead of them, which would prevent them from freely choosing their desired speed. This means that speed choice is more likely to be under volitional control during off-peak hours than during peak hours. Driving behavior recorded on peak hours (from 7 to 9 am and from 4 to 7 pm on weekdays) was therefore excluded from our analyses.

3.4 Behavioural effects of PAYD on overall percentage of speeding

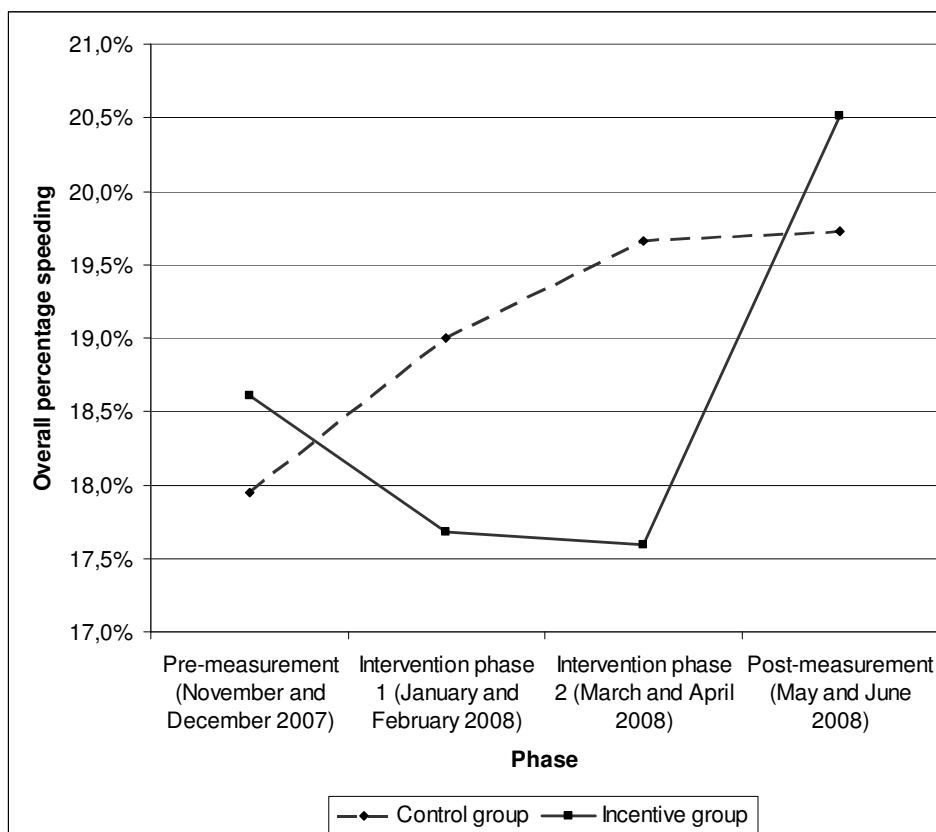


Figure 2 Overall percentage speeding for incentive and control groups. Adapted from Bolderdijk, Knockaert, Steg & Verhoef (2011)

As can be seen from the figure above, the overall percentage of speeding increased from pre-measurement to post-measurement for both the incentive and control group (see Figure 2). More importantly, the effect of condition depended on phase. The percentage of speeding of participants in the incentive group decreased after the financial incentive was introduced (pre-measurement = 18.6%, intervention phase 1 = 17.7%, $M_{\text{difference}} = -.9\%$, $F(1,99) = 13.82$, $p < .001$, $\eta^2_p = .122$), remained at the same level during the intervention (intervention phase 1 = 17.7%, intervention phase 2 = 17.6%, $M_{\text{difference}} = -.1\%$, n.s.), and increased after the financial incentive was removed (intervention phase 2 = 17.6%, post-measurement = 20.5%, $M_{\text{difference}} = +2.9\%$, $F(1,99) = 22.77$, $p < .001$, $\eta^2_p = .187$).

Conversely, the percentage speeding of participants in the control group consistently increased as the experiment progressed (pre-measurement = 17.9%, intervention phase 1 = 19.0%, intervention phase 2 = 19.7%, post-measurement = 19.7%, $M_{\text{pre-post measurement}} = +1.8\%$, $F(1,40) = 5.29$, $p < .05$, $\eta^2_p = .117$, other contrasts were not significant). We discuss this finding in more detail in the next Section.

In sum, the incentive group reduced speeding after the financial incentive was introduced, and increased speeding when the financial incentive was removed. This pattern of results is unlikely to be caused by extraneous variables, as the control group

did not display a parallel drop in speeding during the intervention period. These results therefore suggest that PAYD reduced overall speeding, but only as long as the incentive was in place.

3.5 Effects of PAYD on the percentage of speeding on different road types

Additionally, we compared the percentage of speeding in the incentive group during the unrewarded periods (pre- and post-measurement) with the percentage of speeding during the rewarded periods (the two intervention phases), for all five road types separately. This allowed us to directly test whether the effect of PAYD on speeding differs for different road types. The means and standard errors are displayed below.

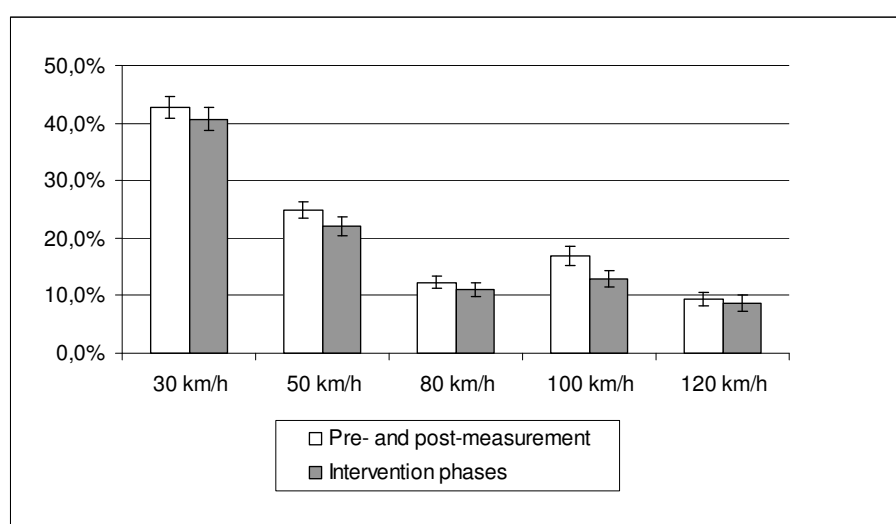


Figure 3 Overall percentage speeding and standard errors for the incentive group, across different road types. Adapted from Bolderdijk, Knockaert, Steg & Verhoef (2011)

As can be seen from the figure above, the percentage speeding was lower during the rewarded (intervention phases) than during the unrewarded periods (pre- and post-measurement). Moreover, the percentage of speeding was higher on roads with lower speed limits. Whereas participants exceeded the speed limit by 6% or more for almost half of the distance travelled (42%) on 30 km/h roads, speed limits were only exceeded by 6% or more for just 10% of the distance travelled at 120 km/h roads. Interestingly, the difference in percentage speeding under rewarded versus unrewarded periods depends on road type. As can be seen from Figure 3, it appears that PAYD exerts the strongest effects on 50, 80 and 100 km/h roads.

3.6 Effects of PAYD on mileage and nighttime driving

Our main interest was in testing whether the financial incentive would influence speeding. However, as indicated above, we also tested whether PAYD affected total distance travelled and distance driven on weekend nights. Unlike other PAYD pilots (Buxbaum, 2006), we were not able to demonstrate PAYD resulted in reductions in mileage or in reductions in driving on weekend nighttime hours.

4 LESSONS LEARNED

4.1 Some behaviours are easier to modify than others

In a randomized controlled field experiment, we found that PAYD resulted in modest, but significant reductions in speeding of young drivers. However, we could not demonstrate an effect of PAYD on travel volume (mileage and nighttime driving). Why was this the case? The obvious answer would be that participants thought that the largest part (30 Euro) of the monthly discount could be earned by keeping the speed limit, and only a smaller part (15 and 5 Euro) could be earned by reducing mileage and avoiding weekend nighttime driving, respectively. In other words, participants may have seen more benefit in changing driving style (speeding) than in changing travel volume or time of travel.

Alternatively, one could argue that reducing travel volume requires planning (Gärling & Schuitema, 2007), and may be experienced as more effortful than changing driving speed. In fact, when a small sample of participants was interviewed about their experiences with the experiment, most indicated that reducing mileage and avoiding nighttime driving was very difficult. Reduction of driving speed contrarily does not require planning and does require less substantial behaviour changes. So, it may be easier and less costly for drivers to change driving style than driving volume, which can help to explain why there were effects of PAYD on speed choice, but not on mileage and weekend nighttime driving.

4.2 The knowledge of being monitored can alter driving behaviour

It can be seen from Figure 2 that the percentage of speeding, both in the control and incentive group, increases between the pre- and post-measurement phases. Moreover, the percentage of speeding in the control group consistently increased during all four phases of the experiment. This specific pattern of results may be attributed to seasonal changes (improving weather and traffic conditions) as pre-measurement took place during Winter (November-December), while post-measurement took place during Spring (May-June), in which driving conditions were more favorable (less precipitation, higher temperatures). Although this is a possibility, it does not explain why participants in the control group increased speeding *within* the winter season, that is, from November/December to January/February.

An increase in speeding under similar weather conditions may perhaps be explained by the fact that participants, both in the control and incentive group, were initially aware of the fact that their behavior was monitored via the GPS device and adapted their behavior accordingly, but this awareness faded over time. From prior research (Nielsen & Jovicic, 2003), we know that monitoring driving behavior may have an impact on driving behavior by itself as the knowledge that one is being monitored might deter drivers from speeding, even when no financial consequences are present. The fact that people might change their behavior simply because they are being observed has been documented in other fields as well, and has been attributed to normative concerns (e.g., Bateson et al., 2006). The increase in speeding over time in the control group also corresponds with the

finding that in absence of sanctions for defection, normative behavior tends to decay over time (Andreoni, 1988). So, it seems unlikely that the pattern of speeding observed in the control group can be solely attributed to seasonal changes in weather and traffic conditions. Thus, it seems plausible that increased speeding from pre- to post-measurement is, at least partly, due to the fading awareness of being monitored.

In sum, we unexpectedly found that the very act of installing a GPS device in driver's car may already alter their behavior. However, this effect seems only temporary as it wears off in time.

4.3 PAYD can lead to small, but significant reductions in crash risk

As noted before, the awareness of being monitored may initially have reduced speeding, but, as time passed, this awareness faded, and speeding returned to its 'natural' level. As such, vehicle speeds during post-measurement may be a better reflection of the speed at which participants would normally drive than speed levels during pre-measurement, where the GPS device had been recently installed and might have deterred participants from driving at their regular speeds.

Following this logic, the best possible estimation of the effect of PAYD on speeding might be reflected in the difference in speeding of the incentive group during the second intervention phase (March and April 2008) and after the incentive was taken away (post-measurement, May and June 2008). When doing so, the financial incentive appears to have decreased the percentage of distance travelled during which drivers violated the speed limits by 6% or more from 20.5% to 17.6%. To put it differently, PAYD is estimated to have reduced volitional speeding by 14%, which roughly amounts to a reduction of 39.2 hours per year for the average young driver (assuming an average speed of 50 km/h across all roads, and 14,000 km yearly mileage).

Although these numbers might not appear impressive, one should note that these numbers reflect reductions in actual speeding across all roads participants drove at. As such, the safety gains from PAYD could add significantly to those already made through the use of more conventional speed enforcement tools (e.g., speed cameras and mobile radars), especially as the effects of such tools on driving speed are typically limited to areas where enforcement is active. Also, small differences in driving speed are associated with large differences in crash risk (Elvik, 2006). A reduction of speeding by 5% may lead to as much as a 20% decrease of fatalities in road accidents (OECD/ECMT, 2006). Thus, we conclude that PAYD leads to modest, but relevant reductions in the driving speed of young adults, and thus may prove a valuable tool in helping to reduce the crash risk of young drivers.

4.4 Incentives versus feedback

Participants in the incentive group thus received both feedback and a monetary incentive. By choosing this setup, however, one could argue that the pattern of results obtained in the incentive group might have also occurred without a financial incentive, and could be attributed to the presence of feedback.

We however expect this possibility to be unlikely. First, feedback tends to be effective when presented frequently, and in close proximity to the target behavior (Fischer, 2008), which was not the case in our experiment. Second, considering the limited number of participants that actually visited the website (the majority of participants did not visit the

website in the first experimental phase, let alone during later stages of the experiment), it seems unlikely that the presence of the website, by itself, can account for the pattern of results.

In conclusion, delayed feedback via a website may not be sufficient to promote a change in behavior. The time between the behavior (e.g. speeding) and consequence (e.g. a noticeable change on the feedback site) is too large for drivers to notice an association between the two, and drivers seem not too interested in repeatedly logging into a feedback website.

Other forms of feedback - whether in combination with a financial incentive or as stand-alone interventions - may however prove more promising. Specifically, direct feedback (behavior is immediately followed by feedback) and social feedback (the behavior of individuals is compared to the behavior of others) may prove an effective behavior change tool (Brookhuis & De Waard, 1999; Schultz et al., 2007). We will discuss these options in more details later.

4.5 PAYD does not change driver habits

As is often the case when using extrinsic motivators for altering behavior (cf. monetary consequences), we only found a temporary change in behavior, as long as the incentive was in place. As can be seen from Figure 2, the experimental group returned to their 'natural' speeding levels as soon as the financial incentive was removed. This suggests that, unlike other empirically tested transport interventions (Fujii & Gärling, 2005), PAYD did not change participants' habits and attitudes towards keeping the speed limit. Drivers were solely motivated to reduce their speed due to extrinsic factors (the monetary incentive).

The temporal effect makes sense from social-psychological perspective. According to self-persuasion theory (Aronson, 1999), interventions may lead to lasting changes in behavior when people change their attitudes to be in accordance with their new, voluntarily chosen, behavior. In the case of our field experiment however, there was an obvious external reason to which reductions in speeding could be attributed; a substantial financial incentive. As such, attitudes towards keeping the speed limit did probably not alter, and participants started speeding again when the financial incentive was removed. This suggests that for PAYD to be effective in the long term, it has to be administered indefinitely or at least until youngsters have reached the age at which speeding is no longer intrinsically motivating.

4.6 GPS is not always reliable as a tool to monitor driving behavior

During the course of the experiment, we encountered some problems with the GPS devices. On some occasions (e.g., a loss of GPS signal, for instance due to driving through a tunnel), the GPS device logged on longer intervals (that is, less often than every 100 meters). These observations (which amount to 23.4% of the total distance travelled) were removed from the analyses, as vehicle speed for these longer intervals could not be reliably determined. Moreover, we were forced to discard the data of some participants for the analyses, as we did not have reliable data across all different measurement periods because failure of their on-board units.

These problems signal that, although GPS is a powerful and versatile tool for implementing PAYD schemes, it is a liability. We therefore strongly advise future PAYD

systems to only utilize a GPS software and registration systems that have been thoroughly test prior to implementation. Even so, given the inherent instability of the GPS system, errors are unavoidable. When handing out financial penalties for risky behaviors, it may be better to err on the conservative side: when poor data makes it hard to determine whether a risky behavior has occurred or not, the driver should be granted the benefit of the doubt.

Nevertheless, PAYD did significantly reduce speed violations, which suggest that, if anything, our results reflect a somewhat conservative test of the effect of PAYD on speeding.

4.7 Privacy issues are not necessary a barrier to the implementation of PAYD

In the field experiment, we used GPS technology to be able to directly monitor driving behavior, and provide parallel financial consequences. This particular monitoring aspect has been argued to prove problematic for wider implementation and acceptance of PAYD. When asked for the lack of interest in participating in an American PAYD pilot for instance, privacy concerns about the constant monitoring of behavior were one of the most frequently cited reasons by motorists (Buxbaum, 2006): they claimed to feel uncomfortable about the awareness of being monitored. Several researchers have argued that privacy concerns may be an important reason why public acceptability of pricing policies is generally low (Jones, 1998; Litman, 2005; Schlag & Teubel, 1997). This poses an important problem to policy makers aiming to implement GPS-based PAYD, since low acceptability ratings can be a serious barrier to policy implementation.

Everyday experience, however, suggests that in other domains, the systematic registration behavior does not cause parallel privacy concerns. Consumers' massive adoption of loyalty cards, for instance, signals that most people are either not aware that personal information about their shopping patterns are being gathered via loyalty cards, fail to realize the costs of disclosing personal information, or are simply indifferent about disclosing such private information to third parties.

Our personal experience with the project, as well as additional focus groups, also suggests that privacy was not a big issue to most participants in the field experiment. So why is there a gap between what people say and what they actually do when it comes to privacy?

In a soon to be published paper (Bolderdijk et al., 2011b), we argue that this 'privacy paradox' (Norberg et al., 2007) may be a result of motivated cognition (Kunda, 1987): people who have a vested interest in participating in a PAYD scheme are motivated to focus on the potential benefits, rather than costs of GPS devices, leading them to downplay privacy concerns. In other words, when future customers see PAYD as being (financially) attractive for them personally, they are unlikely to raise privacy concerns. This suggests that, provided that potential benefits are clearly communicated to customers, privacy may not be the barrier against implementation of GPS-based that is has been argued to be.

5 RECOMMENDATIONS FOR FUTURE PAY-AS-YOU-DRIVE POLICIES

5.1 Money is not always effective as a tool for behavior change

Money is believed to be a one of the most powerful and universal sources of motivation, and acts both as an incentive (people are likely to engage in behaviors they believe are financially attractive) and reinforcer (people tend to repeat actions that resulted in financial gain; (Lea & Webley, 2006). As such, many have argued that money is an effective tool for behavior change (Stern, 1999; Volpp et al., 2008; Kazdin, 2009), as behavior is most strongly governed by direct, personal consequences (Geller et al., 1982). Simply change the incentives, and behavior will change accordingly.

Indeed, the PAYD field experiment clearly demonstrates that providing financial incentives for maintaining the speed limit can lead to substantial reductions in speeding. Money can create motivation to change, which, in turn may lead to behavior change. These findings match the assumption that people react 'rationally' to money as a tool of persuasion. Penalties (e.g., energy taxes) make behaviors more expensive, and should reduce demand for those behaviors (e.g., energy consumption). Similarly, rewards (e.g., subsidies) make behaviors financially attractive, and should increase demand for those behaviors. Thus, this basic economic framework predicts a monotonic relation between anticipated financial consequences and behavior (Gneezy & Rustichini, 2000b).

Empirical research, however, suggests that these predictions are not always confirmed, especially when financial rewards and penalties are relatively small (Heyman & Ariely, 2004). Financial rewards, for instance, do not necessarily lead to an increase in desired behavior (Bonner et al., 2000). On the contrary, introducing financial consequences can actually result in less, rather than more desired behavior. For instance, financially rewarding volunteers decreased, rather than increased their willingness to keep helping (Gneezy & Rustichini, 2000b). Another study showed that a financial penalty induced parents to pick their children up even later than before the fine was introduced: by paying the fine, parents had purchased the 'right' to be late (Gneezy & Rustichini, 2000a). Paying a penalty for breaking a rule can relieve people of the moral obligation to act appropriately, and thus *stimulate* rule violations.

These examples illustrate that money's persuasive power does not only depend on its instrumental value, but also on how money affects people's cognitions: monetary incentives may undermine people's tendency to consider normative considerations in making decisions. These findings have some important ramifications for attempts to change driving behavior via financial incentives. So when is it a good idea to implement money as a tool for change, and when not?

This question is hard to answer in a few paragraphs, but some general guidelines have emerged from the literature:

- 1) Extrinsic consequences (cf. money) is particularly effective as tool to motivate behavior that is mundane, and lacking intrinsic rewards (Bonner et al., 2000). When a task requires autonomy and creativity, money may often do more bad than good (Pink, 2011) in terms of performance.

- 2) The size of financial reward/penalty seems crucial. Particularly small rewards and penalties may have a negative cognitive effect (they crowd out normative considerations), but create no sufficient incentive for change. In the words of Gneezy and Rustichini (2000b) "Pay enough or don't pay at all".

From this perspective, it makes sense that PAYD was so successful in our experiment on changing driving behavior: keeping the speed limit can be a rather boring affair for young drivers. At the same time, they faced a rather large incentive for doing so: they could earn up to 50 euros per month for doing so.

This conclusion also highlights the conditions under which PAYD schemes can be effective to alter driving behavior: it has to offer a relatively large incentive for a behavior that is relatively convenient to complete (e.g., maintaining the speed limit, rather than reducing travel volume or changing the time of travel). However, it may not be economically feasible for insurance companies to provide large rewards for safe driving behavior practices. Luckily, the motivational value of money is not only dependent on incentive size. In the next section, we will discuss how the motivational impact of financial incentives can be maximized by employing some psychological principles of persuasion.

5.2 Designing 'smart' incentive structures

Our field experiment included a rather large incentive (50 euros), but such a large reward may not be feasible for insurance companies aiming to implement PAYD systematically. Below, we present some insights policy makers may use when trying to maximize the behavioral effects of the financial incentives their PAYD system may offer.

5.2.1 Capitalize on loss aversion

According to classic economic models, effort is linearly related to incentive size: the degree of effort people are willing to exert should depend on the amount of financial compensation (Gneezy & Rustichini, 2000b). Whether financial compensation takes the form of receiving money that was not owned before (e.g., subsidy or bonus) or having to give up less of previously owned money (e.g., tax-cut or discount) should thus be irrelevant. As both represent the same monetary value, they should result in equivalent levels of effort.

However, psychological research suggests that the source of monetary reward does make a difference in terms of effort. Incurring losses is generally perceived as more painful than foregoing gains of equal magnitude ('loss aversion', Kahneman & Tversky, 1979). So, people may exert more effort to reclaim money they previously owned than money they did not own before. We thus argue that previously owned money leads to more effort because it involves the risk of *losing* (Bolderdijk, 2011).

Incentive schemes could capitalize on this knowledge. For instance, providing provisional rewards *before* a desired behavior occurs could pose a useful alternative to conventional post-behavior rewards (in which reward are administered after desired behavior occurs). Insurance companies could for instance provide new customers a provisional 10% discount on their insurance fee (e.g. they are promised a 100 euro rebate by the end of the year, or a non-monetary reward) provided that they refrain from risky behavior (as measured by in-car GPS-devices).

Such a reward structure may allow insurance companies to capitalize on loss aversion: failing to *retain* a previously owned reward will be perceived as a loss, which may be more motivating than failing to *attain* a reward that was not in one's possession before. Thus, theoretically, it holds the promise of enhancing the effectiveness (or price elasticity) of rewards without changing the actual incentive size.

However, whether drivers perceive they are actually *losing* money will depend on how the reward scheme is structured. Having to pay money from an *actual* provisionally endowed travel budget is more likely to feel like a loss, and thus more motivating, than when money is deducted from a 'virtual' travel budget that has never been in one's possession. This interesting possibility warrants further research. Based on our overview of the literature, we expect financial incentives (including PAYD schemes) to be more effective when they involve financial loss, rather than gain.

5.2.2 Incentivize those behaviors that are most eligible to change, and facilitate behavior change

Our field experiment, as well as other literature (e.g. see also the parallel ITF/OECD discussion paper by Fridstrom, 2011), suggests it may be easier to change driving behaviors that are instantaneously decided and require only minor effort (e.g. keeping the speed limit, not overtaking, maintaining distance to other drivers), than behavior that requires planning. Consequently, the persuasive impact provided by the monetary incentives in PAYD schemes may be maximized when they focus on altering behaviors that are eligible to change. The effects of PAYD may thus be maximized when combined with other interventions that facilitate behavior change. For instance: although we did not find an effect on driving volume, PAYD may still prove helpful in reducing travel volume when reduced travel volume actively facilitated (e.g., by encouraging employees to work at home, or promoting public transport).

5.2.3 Combine incentives with direct and social feedback

As argued before, delayed feedback (at least through a website onto which customers are required to log in voluntarily) may not have had an additional motivational effect on top of that created by the financial incentive itself. However, other forms of feedback could prove useful additions to future PAYD schemes.

The technology has emerged to directly monitor driving behavior and give in-car feedback (Brookhuis & De Waard, 1999). Future PAYD schemes could utilize such direct feedback systems. The presence of a direct feedback device in the car may present drivers a constant reminder of the financial consequences (e.g. discount on insurance fee lost) that are tied to their individual driving decisions, thereby maximizing the persuasive impact of the financial incentive posed by the PAYD scheme (cf. Mazureck & Hattem, 2006).

Whereas instant feedback acts as an antecedent (as it signals the presence of financial consequences), social feedback may provide motivating consequences in and of itself. In social feedback systems, people's own behavior is compared against that of significant others. Psychological research suggests that people experience discomfort when they are deviating from what others are doing. Consequently people are (often outside their awareness) inclined to follow the behavior of others. Presenting people with information on the behavior of others (social feedback) may thus offer a way to motivate individuals to change their behavior in accordance with the norm (Cialdini & Goldstein, 2004).

In a field experiment, residents received feedback on the how their energy consumption per day compared against that of the average consumption in their neighborhood (Schultz et al., 2007). As predicted, those who used more energy than average reduced their consumption. The norm seems to act as a 'magnet', attracting those who deviate to the middle. However, these researchers also found a 'boomerang' effect: residents who learned that they already used less energy than average *increased*, rather than decreased their energy consumption. This unintended effect was however curbed when social feedback was accompanied by a non-monetary reward (a positive emoticon, see figure below).

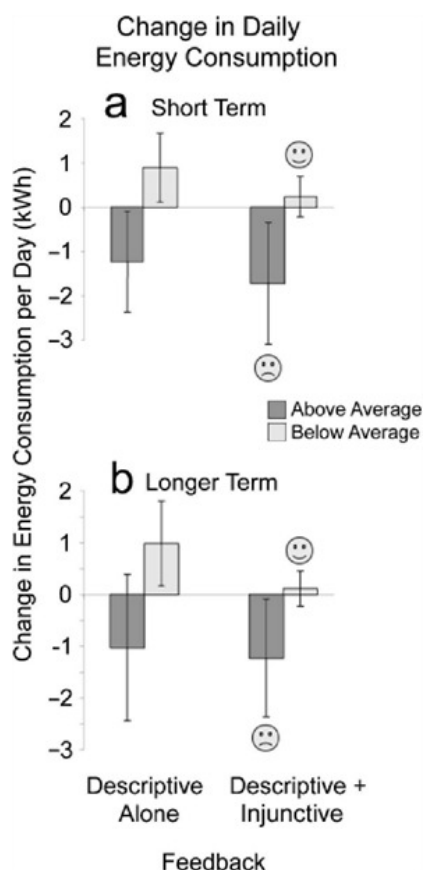


Figure 4 Social influence can change behavior (Schultz et al., 2007)

These empirical findings suggest that direct and social feedback may prove useful additions to future PAYD schemes, and may maximize the likelihood of behavior change occurring due to the presence of a financial incentive. However, more research is needed as, to our knowledge, empirical research has not yet investigated the behavioral effects of the combination of social feedback and financial incentive.

5.2.4 Do not exclusively focus on monetary consequences when attempting to change behavior

Many safety and environmental campaigns appear to rest on the assumption that in order for behavior change to occur, interventions have to appeal to short-term self-

interest, for instance by highlighting the financial savings that can be achieved through lesser and safer driving (Thogersen & Crompton, 2009). However, this strategy may not always be effective given that, as argued before, the financial savings involved in specific desirable actions are typically quite low.

With only very minor monetary benefits involved, the strategy of communicating financial gains may actually be ineffective. In fact, it is even possible that communicating the exact financial gains of specific behaviors may, ironically, decrease, rather than increase motivation: it makes people realize that the financial savings are relatively small in relation to the required sacrifice (Heyman & Ariely, 2004).

Thus it seems important to pay attention to the way monetary consequences for pro-environmental behaviour are communicated. When it comes to promoting behaviours that entail negligible monetary benefit, it may be better to couch rewards in terms of normative considerations, either by appealing to environmental sustainability (CO2 emissions prevented), or concerns about the safety of other road users.

In fact, a recent field experiment we conducted (Bolderdijk, 2011) suggests that appealing to environmental consciousness may actually prove more effective in achieving behaviour change than appealing to financial self-interest. We found that an environmental appeal "Do you care about the environment? Get a free tire check" yielded more compliance than a financial appeal "Do you care about your finances? Get a free tire check".

As argued above, monetary consequences may have negative side-effects because they can induce a business mind-set, in which people do not consider normative considerations of their decisions ('Doing the right thing') but instead focus on personal benefits ('What's in it for me?'). Policymakers could attempt to prevent the onset of this business mind-set by positioning monetary rewards and penalties as support for - rather than the ultimate goal of - desirable courses of action. So rather than presenting PAYD-related rewards for safe driving behaviour as being in the economic self-interest of drivers, rewards could alternatively be presented as recognition and appreciation for the socially responsible driver.

6 CONCLUSIONS

Pay as you drive can potentially be a very effective tool for insurance companies to curtail risks, by offering direct financial incentives for safe driving behaviour of their customers. However, the size of the monetary rewards offered in economically sustainable PAYD scheme may not necessarily be sufficient to motivate behaviour change. The persuasive impact of such financial incentives may be maximized when incorporating insights from behavioural science into the design of future PAYD schemes.

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