# RUNNING ON AUTO

A Behavioural discussion of driving safety May 2015

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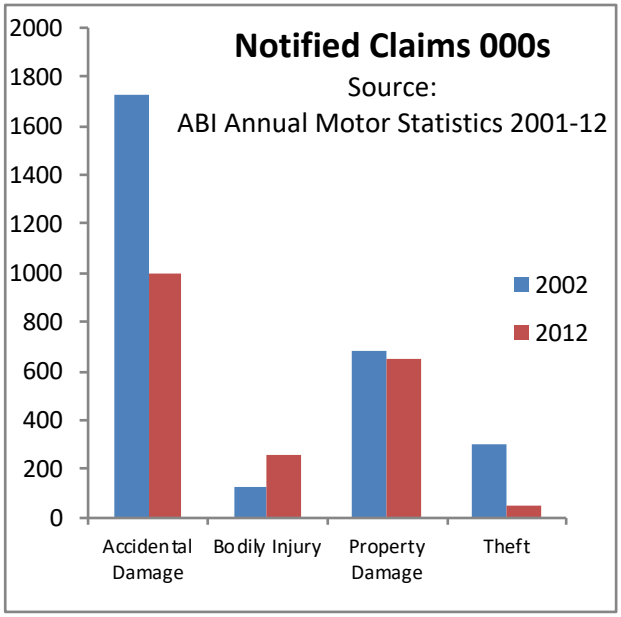
## I. Introduction

The question addressed in this paper is whether more can be done to influence drivers' own behaviour in order to generate further improvements in accident rates. This is particularly pertinent if, as is forecast, the long-term trend of growth in car travel resumes as the economy recovers from the financial crisis.

At the same time that great advances are being made in vehicle technology and safety, the UK is facing dramatic inflation in the costs of driving-related harm to property and people. Whiplash claims, in particular, are playing a significant part in pushing up the costs of insurance. This paper applies concepts from behavioural economics to an analysis of driving errors, and considers how this approach might provide ideas for future policy.



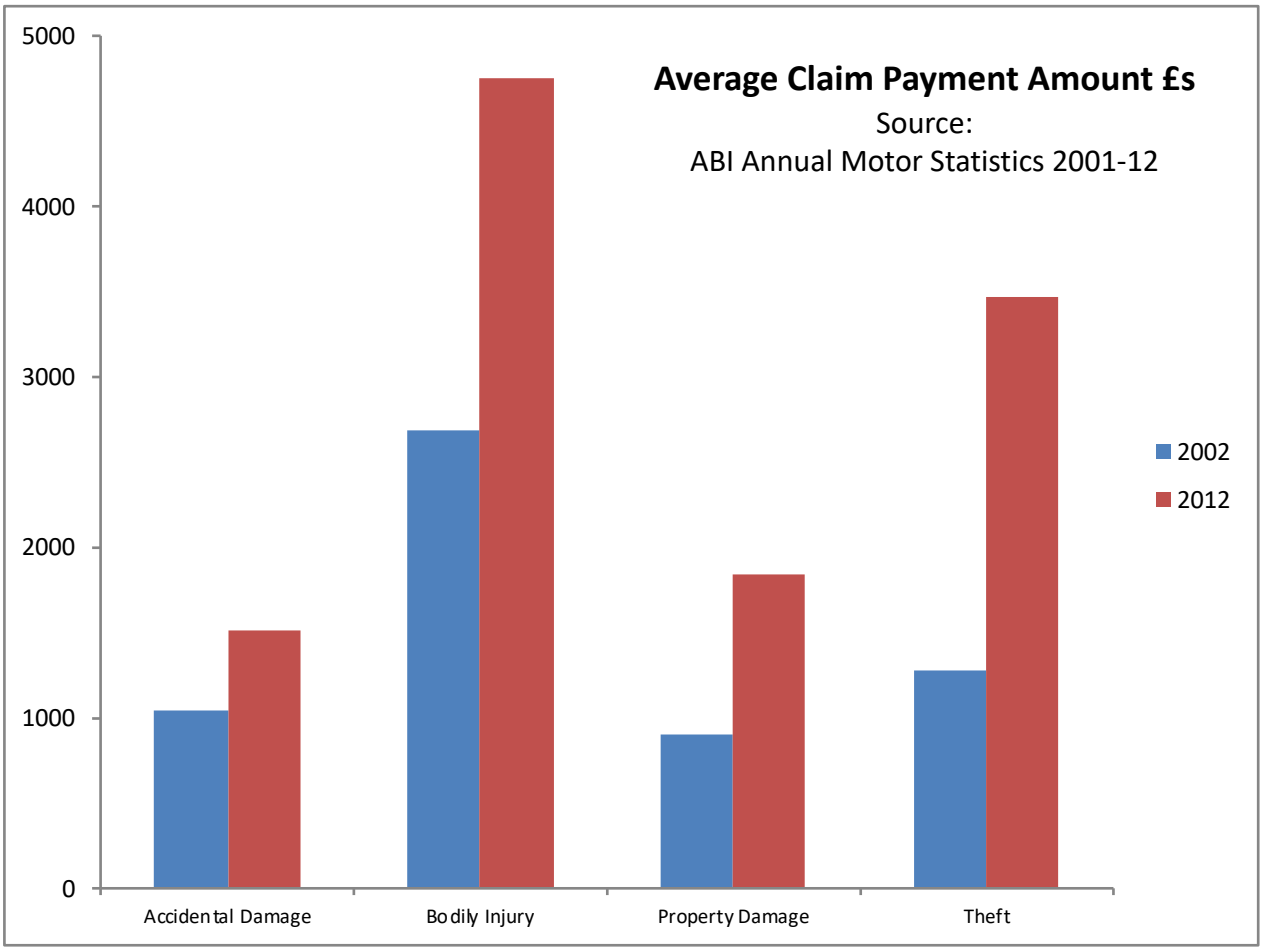

Attitudes to vehicle use are changing, as concerns around climate change and quality of life lead to the proliferation of new ideas around work, travel, and the sharing of outdoor space. Like many other countries, the UK has developed measures of national "well-being", known as the Happiness Index. These include statistics on people's perceptions of their transport options, their local environment, and their health. Early data from this exercise suggests that households' transport options to work and key services is worsening, as is people's satisfaction with their own health[4],

Vehicle safety technology has advanced to the stage at which Fully Automated Driving (FAD) is now a near-future prospect. The appeal to drivers lies partly in the delegation of responsibility for the least pleasant or boring experiences associated with driving. On the other hand some drivers will fear the loss of control, and with it the diminution of driving as a "thrill-seeking" behaviour[5]. Behavioural science offers some clues as to how behaviour may adapt to new technologies, and how strategies might be designed to these motivations might be harnessed as a force for good.

[4] ONS. 2015. Measuring what matters. http://www.ons.gov.uk/ons/guide-method/user-guidance/well-being/index.html
[5] Payre, W., Cestac, J., & Delhomme, P. (2014). Intention to use a fully automated car: Attitudes and a priori acceptability. *Transportation Research Part F: Traffic Psychology and Behaviour,* Transportation Research Part F: Traffic Psychology and Behaviour, 2014.

## II.Motor Insurance Data[6]

In 2013 UK drivers spent more than £13bn on motor insurance with member companies of the Association of British Insurers, and the insurance industry paid out £17.1m per day in private car claims[7]. Whilst the total number of claims notified on these policies fell in the decade to 2012, as did the annual mileage travelled[8], the average claim amount rose significantly and the share of causes of claims also changed. Whilst claims for theft fell from 12% of the total (by number) in 2002 to just




3% in 2012, the share of the total accounted for by bodily injury grew three-fold from 5% to 15%. Over the same period the average insurance payment amount for bodily injury claims rose from £2,881 to £4,756. Part of this change has been blamed on an *"epidemic of whiplash claims, fraudulent crashes, and the cost of uninsured drivers"*[9]. The ABI estimates that whiplash claims alone now cost insurers £2bn a year and add £90 to drivers' annual car insurance premiums, despite several recent initiatives by government and insurers to better combat the problem of inflated or fraudulent claims[10].

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[6] Source: Association of British Insurers (ABI) *Annual Motor Statistics 2001-12* . All data cited exclude Windscreen-only claims, and claims settled at zero cost. ABI. London (2015).

[7] ABI *"Key Facts 2014"* ABI, London, p6 https://www.abi.org.uk/~/media/Files/Documents/Publications/Public/2014/Key%20Facts/ABI%20Key%20Facts%202014.pdf Accessed 17th February 2015

[8] Competition & Markets Authority (CMA) *Private Motor Insurance Market Investigation: Final Report* CMA. London. 24 September 2014. p(2)13, Table 2.4 https://assets.digital.cabinet-office.gov.uk/media/5421c2ade5274a1314000001/Final_report.pdf Accessed 17 February 2015

[9] Datamonitor *"Private motor insurers face discontent as rates and claims continue to rise"* MarketWatch: Financial Services, August 2012 www.datamonitor.com Accessed 17 February 2015

[10] ABI *"Whiplash claims"* webpage, last updated 13th November 2014 https://www.abi.org.uk/Insurance-and-savings/Topics-and-issues/Personal-injury-claims/Whiplash-claims Accessed 17 February 2015

Despite these trends in personal injury claims, however, accidental damage remained the leading type of claim by frequency, accounting for more than 60% of claims, at an average cost of around £1300. The second most common type of claim is for damage to property owned by a third party.

Despite the recent phenomenon of growth in personal injury claims, *"crash for cash"* and similar frauds, which can be associated with the rising average cost of a claim, the general downward trend in the claims rate is very positive. Much of this is attributed to technological advances in cars and road infrastructure.

The paper considers the issue within the context of developments in behavioural economics, and of the popularity of "nudge"[11] policies. The title draws on Daniel Kahneman's Nobel prize-winning research into our decision-making processes. In his best-selling book *"Thinking, fast and slow",* Kahneman describes two mental decision-making systems[12]:

"System 1 operates automatically and quickly, with little or no effort and no sense of voluntary control. System 2 allocates attention to the effortful mental activities that demand it, including complex computations. The operations of System 2 are often associated with the subjective experience of agency, choice, and concentration."[13]

To what extent are accidents the result of failures of decision-making, either because our automatic "System 1" responses mislead us, or because we do not fully account for risks within our more reflective "System 2" decisions?

Many tasks are best left to automatic responses, but we run the risk that the more we are protected from our own decision-making flaws, the more we lose our autonomy and responsibility, and the less we engage with the environment around us. In the end the "choice architecture" could turn more of us, more often into risk-takers, protected from the consequences of our decisions or the delegation of decisions.

This approach to the issue of vehicle accidents suggests that we should seek ways to offset the rise of automatic, protective systems through an increase in engagement with wider responsibilities. Nowhere is this strategy more relevant than in the progressive shift towards the driverless car, which looks to become a feature of our roads within five to 10 years, with a transition period within which the driver may cede increasing levels of responsibility to the vehicle.

This paper first introduces some of the most relevant concepts from behavioural economics, and its adoption by policymakers. Whilst Kahneman's division of decision-making into System 1 and System 2 provides a clear framework for this approach, we need to understand the short-cuts that we take in our everyday decisions, whether automatic or reflective, that affect the outcomes. We also need to understand how people assess risks, both large and small, and the reasons why even the most risk-averse can take ill-judged risks with predictable consequences.

We use this framework of behavioural economics to consider the relevance of these concepts to driver behaviour. We assess various interventions designed to prevent accidents or mitigate their impact,

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[11] Thaler and Sunstein claim that an intervention in decisions is a "nudge" when it does not reduce the set of choices available, but alters the "choice architecture" in favour of the option that most benefits the individual concerned. Thaler, R. and Sunstein, C. (2008) *Nudge: Improving decisions about health, wealth and happiness.* New Haven: Yale University Press

[12] Kahneman attributes the dual-systems approach to Stanovich and West (2000): Stanovich, K. and West, R. (2000), "Individual differences in reasoning: Implications for the rationality debate?" *Behavioral and Brain Sciences* 23(5): 645-726.

[13] Kahneman, D. (2011). *Thinking, fast and slow.* London: Allen Lane, pp20-21

and take a look forward, to hypothesise with regard to the potential behavioural effects of the latest vehicle technologies, leading eventually to the driverless car. This analysis is then drawn together to offer suggestions for policymakers that draw on the findings from behavioural economics, to maximise the safety of car travel.

## III. Behavioural Economics: Understanding our Mistakes

We all like to think that we make sensible, considered decisions and judgements. Traditionally economists have liked to think that too. Classical models of economic behaviour have assumed rational, consistent and predictable decision-making, and economic and policy interventions have been designed on that basis. In the early 1970s such assumptions began to be systematically questioned by psychologists and economists, and a body of experimental work began to provide compelling evidence that our decision-making and reasoning is more complex and unpredictable than standard economic theory had assumed. The discipline of behavioural economics was born.

An essential starting point for understanding how we make judgements and decisions is to recognise that there are dual processes at work, described – influentially if not imaginatively – as System 1 and System 2[14]. System 2, perhaps, is how we like to think we think: we deliberate, we consider, we weigh up options. Our thought processes are conscious – we are aware of ourselves concentrating and, if asked, could almost certainly describe the step-by-step progression of our thoughts. But our reasoning is often not like this, but instead swift and instinctive – or System 1. This is our "cognitive unconscious"[15]: we arrive at judgements effortlessly and without deliberation; often the underlying reasons for decisions or actions are unclear to individuals – "it just felt right".

Kahneman has described System 1 as heroic[16] – for without these swift and unconscious decisions and judgements, much of life would become unmanageable. Take catching a cricket ball spiralling high in the air. To understand the likely path of the ball, and to place ourselves at the right place to catch it, in theory demands a whole string of complicated calculations about trajectory, velocity, wind and running speed - the implausibility of taking time out to compute these factors is evident. Instead we unconsciously arrive at the right place (much of the time)[17]. Our everyday interactions too rely heavily on System 1: we unconsciously judge the trustworthiness of another through an instant evaluation of their face[18]; we walk to the shops without thinking about it. Frequently these unconscious and fast judgements are guided by 'heuristics' – shortcuts or rules of thumb which, unbeknownst to us, guide our judgements. Thus catching the cricket ball relies not on analysing all available information, but on using a single rule of thumb – we keep the angle of our gaze upon the ball constant by adjusting our speed, and hence arrive in the right place at the right time[19]. Such rules of thumb may reflect evolutionary adaptations of cognition to the human environment[20].

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[14] Stanovich, K. and West, R. (2000) op. cit note x

[15] Epstein, S. (1994), "Integration of the Cognitive and the Psychodynamic Unconscious". American Psychologist 49(8): 709-724. P. 710

[16] Kahneman, D. (2011) ) op. cit note x

[17] For more on how we catch, see Gigerenzer, G. (2008), *Gut Feelings: Short Cuts to Better Decision Making*. London: Penguin; Shaffer, D. and McBeath, M. (2002), "Baseball Outfielders Maintain a Linear Optical Trajectory When Tracking Uncatchable Fly Balls." *Journal of Experimental Psychology: Human Perception and Performance* 28(2): 335–348

[18] Todorov, A., Pakrashi, M. and Oosterhof, N. (2009), "Evaluating Faces on Trustworthiness after Minimal Time Exposure". Social Cognition 27(6): 813-833.

[19] Gigerenzer (2008); Shaffer and Macbeath (2002). op. cit note x. Different heuristics apply to different catching situations – for instance, whether the ball is heading straight towards us or to one side.

[20] Gigerenzer, G. (2008) op. cit note x

It is not as simple as to say that system 2 is a more mature or thoughtful elder brother of System 1. There are times when gut instinct may outperform deliberative thought, depending upon what the task is[21]. Alternatively through experience and practice our judgements and actions may become intuitive. This is typically what we mean by expert intuition – the police officer who can comprehend a complex situation in a moment, or a sports player who completes a complex manoeuvre under pressure. Indeed sports players in particular suggest that one can think too much[22]. In these cases System 2 seems superseded by a sophisticated System 1 approach, albeit one not based upon heuristics, but upon experience and intuitive recognition of a given situation[23]. And systems of course interact in multiple ways. As example data from system 1, such as feelings and emotions, can be used as information when we come to make decisions[24].

Yet if System 1 is heroic, it is a tragic hero. Daniel Kahneman won the Nobel Prize in Economic Sciences for identifying systematic errors and biases in System 1 judgements and decision-making, and it is awareness of these errors and biases which lies at the heart of behavioural economics. An increasing number of failures of reasoning have been identified; here we focus on some of the most important findings, with an eye on those which may especially inform our understanding of vehicle accidents and their prevention.

***Rules of thumb***

Rules of thumb, functioning unconsciously within our System 1 reasoning, help us to make quick and efficient decisions– but they can also lead to systematic errors and biases, and hence wrong judgements. Many such errors have been identified; here we focus on two of the most significant. First, individuals' assessments of the frequency of phenomena are affected by the ease with which they can be brought to mind – their *availability* to our cognition[25]. Thus people were asked to estimate the frequency of seven letter words ending '-----n-' and '----ing' respectively in four pages of a novel. Logic demands that the first estimate should be higher than the second, since the second group of words are a subset of the first. Yet the words ending 'ing' were emphatically predicted to be more common, an outcome explained by the ease of bringing such words to mind[26]. Such examples can appear trivial, but this 'availability heuristic' has implications for our real world decision-making. People who have experienced a flood, for instance, are more likely to take out flood insurance irrespective of the current risk – because the danger is easily called to mind[27]. As a corollary, those with no experience of a flood (or serious car accident or similar hazard) may underestimate the frequency of the likely risk, and underinsure or undertake risky behaviours. Kahneman notes that:

"A plane crash that attracts media coverage will temporarily alter your feelings about the safety of flying. Accidents are on your mind, for a while, after you see a car burning at the side of the road, and the world is for a while a more dangerous place."[28]

In the longer term recollections that provoke strong emotive responses will most affect decisions[29].

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[21] Gigerenzer, G. (2008) op. cit note x

[22] Thaler, R. and Sunstein, C. (2009), *Nudge.* London: Penguin.

[23] Kahneman, D. (2011) op. cit. note x

[24] Schwarz, N. (2012), "Feelings-as-Information Theory" in P. Van Lange, A. Kruglanski and E. Higgins (eds.), *Handbook of Theories of Social Psychology*. London: Sage.

[25] Tversky, A. and Kahneman, D. (1974), "Judgment under Uncertainty: Heuristics and Biases." *Science* 185 (4157): 1124-1131

[26] Tversky, A. and Kahneman, D. (1983), "Extensional Versus Intuitive Reasoning: The Conjunction Fallacy in Probability Judgment." *Psychological Review* 90 (4): 293-315.

[27] Baumann, D. and Sims, J. 1978. "Flood Insurance: Some Determinants of Adoption." *Economic Geography* 54(3): 189-196

[28] Kahneman (2011) op. cit. note x p.130

[29] Slovic, P. L., Finucane, M. G., Peters, E., & MacGregor, D. (2007). The affect heuristic. *European Journal of Operational Research, 177*(3), 1333-1352.

Another useful but sometimes troublesome rule of thumb is the "anchoring and adjustment heuristic". To make an assessment of a value, a probability or even a behaviour, you need a starting point – an anchor. But this anchor can be arbitrary (and easily manipulated). As an example, people were allocated numbers from an apparently random turn of a wheel of fortune – some were given the number 10, others 65. They were asked in quick succession to estimate whether the percentage of African countries in the UN was higher or lower than this figure, and what their best estimate of the percentage might be. For those given the number 10, the best estimate averaged 25; for those given 65, it averaged 45[30]. Again, the mistake seems trivial. But, as we shall describe below, the anchor and adjustment heuristic captures well how people may respond to road speed limits – with sometimes negative consequences.

***Loss aversion***

A second and highly influential insight, again identified by Kahneman and Tversky, is that individuals are loss averse: we value a loss much more highly than an equivalent gain. The classic experiment focuses upon an embossed mug. Students are given the mug, and then asked how much they would sell it for; others are not given the mug, and asked how they would buy it for. Those in possession are found to value the mug at a significantly higher price – a finding replicated in numerous other contexts. There seems to be some pain in giving up the things we own, a phenomenon which has been explained as an evolutionary predisposition, embedded in System 1, to protect what we have[31]. From this basic principle of loss aversion, three other insights follow. First, the value we attribute to something depends upon our reference point – our understanding, in other words, of whether we will experience a gain or a loss. Second, there is an endowment effect – if we possess something (whether a mug, an extra day's paid holiday or a pension), we value it more highly. Third, there is a "status quo bias" – we tend to prefer on to what we have rather than to make changes.

***Framing***

How we decide and what we choose depends upon how a decision is framed. How patients respond to the risk of a medical procedure depends upon the framing of the risk. We could say that 90% of patients will be alive after five years; or we could say that 10% will be dead. Logically the situation is identical. But in a trial, participants were more likely to support the procedure in the first case[32]. "Dead" and "alive" are powerful words which frame our choice-making: we are experiencing an emotional System 1 response within our System 2 deliberation. Every decision, of course, takes place in a context – and changing the appearance or feel or presentation of that context, even without changing the actual substantive choice, can be very powerful.

***Living in the present***

We tend to live in the present – as if our future self is a different person about whom we do not need to care very much. This 'present bias' or myopia can be used to explain why we eat too much or save too little – the needs of our future selves may feel insignificant compared to the pleasures of instant consumption[33]. Compounding this present bias may be a failure of imagination – we have no experience of obesity or lung cancer, and so fail to understand the full risk (and pain) to which we are exposing our future selves. Our future selves are also vulnerable to our over-optimism in the present. Excessive optimism seems to permeate human decision-making[34]. We underestimate risks, such as

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[30] Tversky, A. and Kahneman, D. (1974) op. cit note x

[31] For instance, Apicella, C., Azevedo, E., Christakis, N. and Fowler, J. 2014. "Evolutionary Origins of the Endowment Effect." *American Economic Review* 104(6): 1793–1805

[32] Redelmeier, Donald, Paul Rozin and Daniel Kahneman. 1993. "Understanding patients' decisions: cognitive and emotional perspectives." Journal of the American Medical Association 270 (1): 72-76.

[33] O'Donoghue, Ted and Matthew Rabin. 1999. "Doing it now or later." American Economic Review 89 (1): 103-124; Le Grand, Julian. 2008. "The giants of excess: a challenge to the nation's health." Journal of the Royal Statistical Society, Series A 171 (4): 843-856.

[34] Thaler, R. and Sunstein, C. 2009. op. cit note x

the increased probability of contracting lung cancer if we smoke[35]; we tend to overestimate our own capabilities and skills.

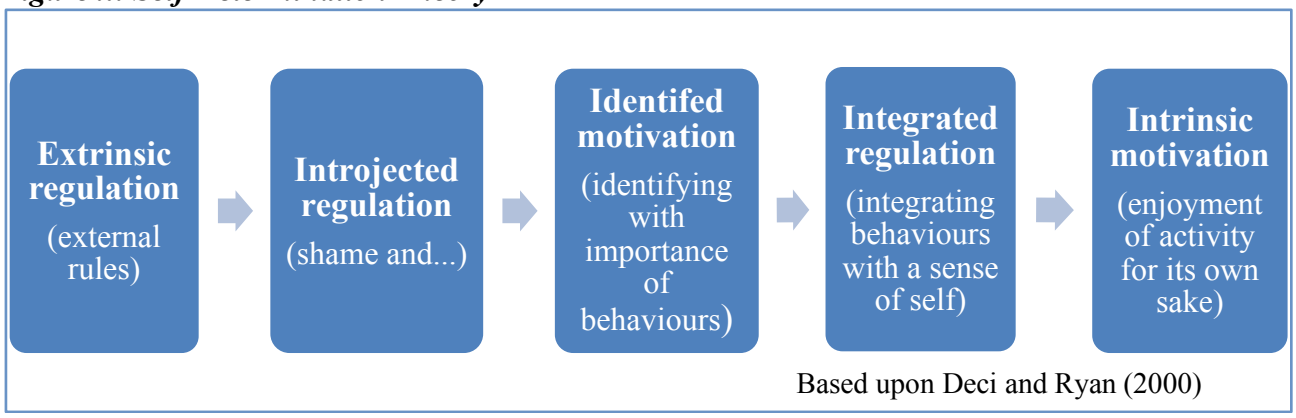
***Visceral decision-making***

A final very human source of error arises from visceral decision-making which has its origin in physical or emotional sensations[36]. One such frailty is weakness of will - a form of present bias by which individuals give in to some kind of temptation. Other states of feeling can also be implicated in biased decision-making – anger, embarrassment and excitement, or sensations such as hunger, tiredness or pain. Research has suggested that there are biologically "hard-wired" differences between men and women which affect the speed and aggression of their responses when other drivers violate their "personal space" [37]. Tackling and reducing such territorial attitudes is one reason for the development of "shared space" initiatives in road infrastructure[38].

***Autonomy***

For a final insight, we move away from the focus on error, and away too for a moment from behavioural economics, to psychological theories of motivation. What motivates individuals to behave in certain ways? Self-determination theory identifies a powerful role for autonomy – the more we perceive that we are autonomous and in control, the more powerful is our motivation[39]. At its strongest we have a complete immersion in a given task, so that our motivation is entirely autonomous and strong (intrinsic regulation). At its weakest we respond entirely to external constraints and incentives beyond our control – the motivation is weak, and if the controls lapse then the behaviour disappears (extrinsic regulation). There are intermediate semi-autonomous states where behaviours are driven by external social pressures such as guilt or shame (introjected regulation), where we identify in some sense with the principles and rightness of the behaviour (identified regulation), or where identification with the behaviour is such that we begin to integrate this with our own sense of self (integrated regulation). Such insights are key to interpreting what types of intervention may change behaviours – and whether the change will be sustained.

***Figure x: Self-Determination Theory***




***Interventions***

[35] Weinstein, Neil, S.E. Marcus and R.P. Moser. 2005. "Smokers' Unrealistic Optimism About Their Risk." Tobacco Control 14 (1): 55-59.

[36] Loewenstein, George. 1996. "Out of Control: Visceral Influences on Behavior." Organizational Behavior and Human Decision Processes 65 (3): 272-292.

[37] Beattie, G. (2008). op. cit note x

[38] Kaparias, I., Bell, M., Miri, A., Chan, C. and Mount, B. (2012). "Analysing the perceptions of pedestrians and drivers to shared space." *Transportation Research Part F: Psychology and Behaviour* 15(3), 297-310.

[39] Deci, Edward and Richard Ryan. 2000. "The "what" and "why" of goal pursuits: human needs and the self-determination of behavior." *Psychological Enquiry* 11 (4): 227-268.

Motivation increases

These insights about our reasoning processes and motivation can help us to design interventions which change behaviours. We can propose new interventions, and understand why existing interventions are effective – or not as effective as expected. But to qualify as "nudges", these interventions need to respect individual autonomy, rather than reduce the driver's choices by direct regulation, penalties or rewards.

In particular, behavioural economics provides a more complete picture of the reasoning failures from which people suffer, and therefore which we may seek to prevent. But it also enables us to manipulate unconscious reasoning and heuristics to encourage the outcomes which are perceived to be desirable. This is the basis of 'nudge' interventions, which subtly manipulate the 'choice architecture' to push individuals towards particular options[40]. Thus healthy foods are placed at the front of the store to encourage their purchase; pensions become opt-out rather than opt-in, an intervention which exploits our tendency to inertia and the status quo. There are of course passionate objections to such interventions: libertarian commentators stress that we should be free to make our mistakes and that others (and especially the state) should not interfere in our decision-making or manipulate our unconscious[41]. Advocates of nudge, however, emphasise that such interventions keep open individuals' freedom to make decisions even as they are pushed towards specific outcomes – in this respect 'nudge' interventions can retain individual autonomy to a greater extent than more traditional regulation and legislation, such as taxes or bans.

When we intervene in order to change people's behaviours, there is a final central point. It is not difficult to design an intervention which creates temporary change. But frequently the desired behaviour disappears over time or when some stimulus (such as a cash incentive) is removed. The challenge, therefore, is to achieve sustained behavioural change.

## IV. Why do accidents happen: Behavioural Insights

Driving a car is not a natural environment. We use and adapt rules of thumb which have developed for very different purposes. A recent study, for instance, describes how the process of steering appears to be similar to, and perhaps derived from, a much more ancient unconscious skill – reaching[42]. Driving a car is initially difficult for most of us. We think hard about what we are doing. The thoughts of a learner driver, as they approach a junction, are multiple and conscious. We are certainly considering the external environment and other cars, but we also have conscious thoughts about the mechanics of controlling the car – look in mirror, foot off the accelerator, brake, clutch down, change gear, look in mirror again. As these mechanics become habitual and unconscious – moving from System 2 to System 1 – we potentially become better drivers: we are, through practice, more likely to be in control of the car; our concentration can be more firmly focused on the external environment around us.

But we have accidents, and lots of them. With very limited exceptions (for instance, fraud), no one has an accident on purpose. Different factors lie behind our mistakes. Some accidents have their origins in intentional hazardous behaviours – speeding, drink-driving, dangerous driving. Others, of course, arise from carelessness or inattention. Others again lie somewhere between intention and carelessness – for instance, being distracted by a mobile phone call. All of these can, ultimately, be described as failures of reasoning which can be understood through the lens of behavioural economics. Some typical failures of reasoning when driving are described in the next sections.

### *System 1 take-over*

[40] Thaler and Sunstein. 2009: p.12. Op cit note x

[41] For instance, Mitchell, G. 2006. 'Libertarian paternalism is an oxymoron' *Northwestern University Law Review* 99: 1245-1277; White, M. 2013. *The Manipulation of Choice.* New York: Palgrave Macmillan.

[42] Benderius, O. and Markkula, G. (2014). *Evidence for a fundamental property of steering.* Paper presented at the Human Factors and Ergonomics Society 58th Annual Meeting, Chicago, October 27-31.

A primary challenge, and source of error, is making sure Systems 1 and 2 kick in in the right way at the right time. We have observed that initially System 1 is heroic – as the movements and processes of driving becoming practised and automatic, we become better drivers. But driving on 'automatic' is clearly a double-edged sword. We want the mechanisms of driving to be automatic, but not that driving should be thoughtless - in other words, that we entirely switch off our systems 2 awareness. Yet this is what we frequently do. Driving along an empty motorway without thinking is a typical systems 1 activity: there are times when we can't remember the last few miles which we have travelled. Such switching off is in certain situations explicitly hazardous – accidents happen if we are not actively thinking when we approach a roundabout, or when we are reversing in a car park, or when we pull out into the fast lane of the motorway. At these moments we want conscious deliberative Systems 2 to be engaged.

Unhelpful System 1 take-over can occur through a second mechanism – the bad habit. Habits are behaviours which become routinized and which we repeat without thinking; they can be good or bad. As we drive over time, bad habits can creep in. The good behaviours which we developed when learning to drive, which were rooted in System 2 active thoughts, gradually fade out - we do not check the mirror as often as we should, or make full observations for hazards at a crossroads. Drivers who are not also motorcyclists are less likely to invest sufficient time to assess the approach of a motorcycle before pulling out from a side road - a common accident scenario, and perhaps another example of inappropriate reliance upon System 1[43]. We can also acquire new bad habits: mobile phone use when driving may for many people be an automatic or habitual behaviour, not a behaviour that is actively thought about[44].

***Getting distracted: System 2 on the wrong path***

But System 2, our conscious and thoughtful self, can be the villain too if its activity is misdirected – if, in other words, we are distracted. Kahneman describes a 'limited budget of attention' which must be used sparingly[45]. His example is from motoring - to undertake a complex mental calculation while making a turn across busy traffic is going to fail in one way or another. Emerging research is beginning to confirm our cognitive limitations. Unsurprisingly investigation of distraction has often focused upon mobile phone use while driving. Evidence increasingly suggests that mobile phone conversations are a cognitive distraction which draws our attention away from driving: during hands-free conversations, for instance, drivers' attention to visual stimuli becomes impaired and narrowed[46]; their reaction times are slower and road awareness reduced[47] . Furthermore, "gaze aversion" has been demonstrated when the content of hands-free calls becomes mentally demanding[48]. Investigations in neuroscience are beginning to specify the process of distraction within the brain. Canadian scientists, in a remarkable feat of engineering, adapted an MRI scanner to become a fully-functioning driving simulator. Kahneman's scenario – a turn across busy traffic – was simulated, and participants were required to converse as they made the turn by listening to questions and making swift true/false answers. Imaging showed striking changes in the brain –activity switched from the brain area responsible for visual processing to the area where decision-making takes place. In other words, the brain function necessary to negotiate the driving hazard was sacrificed in favour of the function

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[43] Crundall, D,, Crundall, E., Clarke, D., & Shahar, A. (2012). "Why do car drivers fail to give way to motorcycles at t-junctions?" *Accident; Analysis and Prevention,* 44(1), 88-96

[44] Bayer, J., & Campbell, S. 2012. "Texting while driving on automatic: Considering the frequency-independent side of habit." *Computers in Human Behavior* 28: 2083-2090.

[45] Kahneman, D. (2011) op. cit. note x; p.23

[46] Strayer, D., Drews, F. and Johnston, W. 2003. "Cell phone-induced failures of visual attention during simulated driving." *Journal of Experimental Psychology - Applied* 9(1): 23–32

[47] Breen J. 2009. *Car telephone use and road safety. Final report. An overview prepared for the European Commission.* http://ec.europa.eu/transport/road_safety/pdf/car_telephone_use_and_road_safety.pdf

[48] Doherty-Sneddon, G. op. cit. note x

required to participate in the conversation. As one of the researchers described it, "there's a finite amount of brain resources that can go around, and something had to give."[49]

Such studies indicate the dangers of distraction. They also imply specifically that that hands-free mobile phone conversations may be just as hazardous as hand-held conservations, a conclusion which seems supported by surveys of real-world incidents[50]. It is the *cognitive* distraction which is hazardous rather than the *motor* distraction of holding the device[51].

**Unhelpful heuristics**

Unconscious rules of thumb may become problematic when driving. The availability heuristic is an obvious example. If we are unable to call to mind an experience of a serious accident, then we are likely to underestimate its probability, and we are also likely to fail to imagine its potentially devastating impact: both factors encourage overly risky driving. Or take the anchor and adjustment heuristic. How do we decide our speed? the speed limit is likely to be our anchor or basis from which we adjust up or down. But there is an error here. The speed limit is a limit, not an anchor to be adjusted up or down; nor is it intended to replace our own reflective judgment on what a safe speed might be.

Road design in recent decades may create the conditions for a further troublesome application of the anchor heuristic. In this case the anchor is perceptual rather than statistical. The heavy regulation of driving and pedestrian areas – through traffic lights, signs, pelican crossings, road markings, kerbs and barriers – creates a strong perception of a partitioned space in which road users can behave as they wish[52]. There can be an associated visceral sense of territory, so that road users respond angrily to perceived to invasions of their space. There is a contrast with the early era of motorised vehicles, when pedestrians, carts and cars negotiated a shared street. In the instances of both the speed limit and the regulated road space, there is an implication that road users – and especially drivers - switch off from consciously thinking about their behaviours. They are principally guided by the external anchor - there is a reduction of autonomy and responsibility, a reliance on external controls alone to create safe driving conditions rather than drivers, pedestrians or cyclists actively evaluating their surroundings. Again, our reflective System 2 capacities are underused.

Multiple other unconscious processes are implicated in driving error. Considerable research, for instance, has explored 'looked but failed to see' incidents, in which cars strike bicycles despite the driver apparently making appropriate observations. There is a suggestion again of an unhelpful cognitive shortcut, that drivers unconsciously sort relevant from irrelevant visual information – and that somehow the sighting of the bicycle is discarded as trivial, especially relative to sighting a car[53].

It may also be that the driving experience can inhibit useful unconscious processes. On a daily basis we make use of social cues in our interactions with others – eye contact, facial expression, body

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[49] Schweizer T., Kan K., Hung Y., Tam F., Naglie G. and Graham S. 2013. "Brain activity during driving with distraction: an immersive fMRI study." Frontiers of Human. Neuroscience 7:53 (February); quotation derived from Kirkey, S. 2013, February 28. *Left-hand turns require "huge" brain power, study shows; add hands-free cellphone and the brain can't cope.* http://o.canada.com/news/left-hand-turns-require-huge-brain-power-study-shows-add-hands-free-cell-phone-and-the-brain-cant-cope

[50] McEvoy, S., Stevenson, M., McCartt, A. et al. 2005. "Role of mobile phones in motor vehicle crashes resulting in hospital attendance: A case-crossover study." *British Medical Journal* 331, 428–435.

[51] Schweizer et al. 2013. op. cit. note x.; Breen, J. 2009. op. cit. note x; World Health Organisation. 2011. *Mobile phone use: a growing problem of driver distraction.* http://www.who.int/violence_injury_prevention/publications/road_traffic/distracted_driving_en.pdf?ua=1;

[52] Toth, G. Undated. *Where the Sidewalk Doesn't End: What Shared Space has to Share*. New York: Project for Public Spaces. http://www.pps.org/reference/shared-space/

[53] Herslund, M.-B. and Jorgensen, N. 2003. "Looked-but-failed-to-see-errors in traffic." *Accident Analysis and Prevention* 35(6): 885-91

language. The physical experience of driving – the distance from the other driver, our enclosure in metal boxes - inhibits our ability to use such cues[54]. Further, it may create a sense of anonymity which encourages aggressive or anti-social behaviours; it numbs our perception that we are interacting with a fellow human being.

**Living and driving in the present**

There is, of course, a benefit derived from risky behaviours. Driving fast or texting while we drive brings some pleasure or advantage – otherwise we would not engage in these activities. Such benefits must be traded-off against the risk we create for our future selves, and it is in this trade-off that there is a bias towards the present. We have already noted our tendency to underestimate the probability of a serious accident because we cannot readily bring it to mind (the availability heuristic). We are also likely to underestimate the accident's impact and effects upon us and upon others, since these are future states which are difficult to imagine and which therefore lack the emotive power to affect immediate decisions. At the same time the present is simply tempting, and the benefits of risky behaviour immediate and tangible. So powerful is the pull of the present that we may unconsciously rearrange our perceptions of risk to justify our behaviours. Thus making an autonomous decision to write a text causes young drivers to believe that road conditions are safer than if they were simply responding to a text which they received. Our awareness of risk is reformed to legitimise our risk-taking choices[55]. This "dual-self" model, in which the impulsive present self is in conflict with the pensive, planned behaviour of the future self, provides a useful basis for the analysis of risk-taking and the design of policies to address risky behaviours[56].

**Over-confidence**

Over-optimism can spill into over-confidence – for if we have never been involved in a serious accident, we may attribute this to our own superior driving skills. Explanations of accidents often tell a tale of over-confidence – driving too fast for the conditions, crashing when overtaking, taking a corner too fast. Research provides evidence of over-confidence about our own driving capabilities, and a common perception that it is other drivers or other road-users, and not ourselves, who create the risk or are at risk[57]. Such over-confidence stretches to explicitly hazardous behaviours: while young drivers are aware that texting while driving is risky, nonetheless the majority persist; similarly awareness of the risks of phone conversations while driving has no effect upon the frequency of calls[58].

Such defiant behaviours in the face of potential risks carry implications for interventions. Road safety campaigns which seek to raise awareness of risks or to induce fear tend to have limited impact, since drivers - and especially those who are most likely to take risks – will perceive that the messages are relevant solely for 'other' drivers whom they perceive to have less skill[59].

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[54] Rakotonirainy, A., Feller, F., and Haworth, N. 2008. "Using in-vehicle avatars to prevent road violence." Pervasive Conference 2008, Sydney19-22 May.

[55] Atchley P., Atwood S. and Boulton A. (2011), "The choice to text and drive in younger drivers: behavior may shape attitude." Accident Analysis and Prevention 43(1):134-42

[56] Fudenberg, D. and Levine, D. (2006). "A Dual-Self Model of Impulse Control." *American Economic Review,* 96(5), 1449-1476.

[57] DeJoy, D. 1989. "The optimism bias and traffic accident risk perception." *Accident Analysis and Prevention*. 21(4): 333-340; Department for Transport. 2010. *Understanding Public Attitudes to Road-User Safety - Literature Review Final Report (Road Safety Research Report No. 112)*. London: Department for Transport.

[58] Atchley, P., Atwood, S., and Boulton, A. 2011. op. cit. note x; Nelson, E., Atchley, P., and Little, T. 2009. "The effects of perception of risk and importance of answering and initiating a cellular phone call while driving." *Accident Analysis and Prevention*, 41, 438-444.

[59] Avineri, E., & Goodwin, P. 2010. *Individual behaviour change: Evidence in transport and public health*. London: Department for Transport.

**Visceral driving**

The notion of visceral driving, where behaviours are driven by emotions and feelings, has entered common parlance in the idea of road rage – hazardous driving caused by anger and even revenge-seeking. There are other times when we drive riskily because of emotions. The guilt or pressure of running late for an appointment may cause us to speed or drive aggressively, even though the time saved, if rationally calculated, is typically minimal and disproportionate to the risk incurred. Our response to other road users can also be visceral. If we are tailgated, for instance, we may speed up or alternatively confront the tailgater by braking suddenly. Driving in itself can be a visceral experience - the feeling of freedom on the open road, the thrill of powerful acceleration or speed; risky driving has been linked with 'sensation-seeking'[60]. In all these cases our feelings, as facet of our swift System 1 responses, may lead us to suboptimal decisions and risky behaviours.

**Norms and cultures**

Driving behaviours may be rooted in beliefs and norms about what is acceptable and expected. Peer pressure can push us to engage in risky behaviours to secure social approval, whether we are drivers, pedestrians or cyclists: aggressive and speedy driving, especially among young people, is linked to peer pressure[61]; so too is reluctance to wear a cycle helmet[62]. Our disregard for specific rules of the road may be grounded in a normative suspicion of authority and of over-fussy 'health and safety'; alternatively we may perceive that, because many drivers apparently break the speed limit, we are justified so behaving[63]. Norms, however, can also underpin 'safe' behaviours: compliance with rules of the road can be driven, at least in part, by normative socialisation that such compliance is appropriate[64]. Once again there is a particular pattern of decision-making, whereby our behaviours are underpinned by assumptions and feelings derived swiftly and without deliberation from System 1.

**Excessive speed**

Driving too fast is a risky behaviour which increases the frequency and impact of accidents. From a behavioural economics perspective it is not a unitary phenomenon. The origins of excessive speed might be:

- System 1 take-over: we fail to pay sufficient attention to our environment or to our driving, so that we neglect a speed limit sign, drift over the limit, or fail to take into account developments in the driving environment, such as weather or traffic conditions.
- System 2 distraction: our attention is taken away from our speed by the radio or some other distraction.
- Over-optimism and poor imagination: we underestimate the probability of an accident and its potential impact on us or others; we over-estimate our driving skills so that we believe we can drive at speed when others cannot.
- Visceral driving: we drive fast and accelerate hard because it is exciting and tempting.
- Peer pressure: it is impressive to drive fast, and we would lose social status if we did not; in any case, everyone else breaks the speed limit.

In the first two cases speedy driving is unintentional; in the last three deliberate.

[60] Jonah , B.A., Thiessen, R. and Au-Yeung, E. (2001). Sensation Seeking, Risky Driving and Behavioral Adaptation. Accident Analysis and Prevention, 33: 679-684

[61] Rolls G. and Ingham R (1992). *'Safe' and 'Unsafe' - A Comparative Study of Younger Male Drivers.* Basingstoke: AA Foundation for Road Safety Research.

[62] For example, Loubeau, P. (2000) Exploration of the barriers to bicycle helmet use among 12 and 13 year old children. Accident Analysis and Prevention, 32, 111–115.

[63] Musselwhite, C., Avineri, E., Fulcher, E. and Susilo, Y. 2010. *Understanding Public Attitudes to Road-User Safety - Literature Review Final Report (Road Safety Research Report No. 112).* London: Department for Transport.

[64] Senserrick, T. (2006), "Reducing Young Driver Road Trauma: Guidance and Optimism for the Future." *Injury Prevention*12 (Suppl I): i56–i60.

Driving errors, in sum, can have different psychological origins. Some may simply be carelessness. Others involve more substantive intentionality – a conscious decision, for instance, to break the speed limit. Yet even such intentional behaviours are often grounded in cognitive biases and errors – whether normative pressure, over –confidence or a variety of erroneous rules of thumb. As box x shows in the cases of speeding, the same risky behaviour may have different bases; different interventions are likely to be required to remedy different psychological errors.

## V.Behavioural Interventions

Understanding of the role of reasoning failures in driving accidents indicates that conventional means of intervention are likely to have only limited effect. Policy-makers have typically relied upon law enforcement and education campaigns to constrain and change risky road behaviours. But both enforcement and education programmes carry assumptions that road users will make rational and predictable cost-benefit decisions which further their own interests[65]. The assumption, in other words, is of a cool, calm and calculated system 2 response.

But because of the various reasoning failures which underlie driving errors, neither of these interventions is are likely to be fully successful. Education programmes assume that, when presented with comprehensive information, motorists should amend their behaviour accordingly in a rational manner – and become safer drivers. But a putative mechanism of this kind fails to account for unconscious biases and cultural preferences. Daniel Kahneman is pessimistic about individuals' general capacity to overcome their biases: "I'm really not optimistic. Most decision makers will trust their own intuitions because they think they see the situation clearly. It's a special exercise to question your own intuitions."[66] If, for instance, an individual believes that they are an especially skilled driver – on account of various biases or erroneous heuristics – then they may infer that the information applies to others, not to themselves.

For law enforcement interventions to be effective, motorists should temper their risky driving in order to avoid penalties and punishments. But there are reasons why they may not. As we have observed, risky driving is perceived to bring pleasure or advantage to the individual. The scale of the punishment – and the likelihood of being caught – must be of sufficient magnitude to outweigh the benefit of hazardous driving. This in turn points to a further problem. Law enforcement is a form of extrinsic control of behaviour – the change of behaviour does not become internalised within the individual. According to self-determination theory (px above), this is a weak form of motivation; importantly, as soon as the extrinsic control is lifted (or perceived to be lifted) the undesirable behaviours return. Slowing for a speed camera and then returning to an excessive speed is an obvious instance. Many risky or aggressive driving behaviours are, further, simply hard to monitor and penalise, so that a reliance on extrinsic control is unlikely to be a comprehensive solution. Finally, law enforcement primarily seeks to deter intentional behaviours. It is not necessarily a powerful tool to combat simple carelessness or thoughtlessness.

That is not to say that education or enforcement never work. Plainly they can have an effect, and there is evidence, for instance, that speed cameras are effective in improving road safety[67]. But they will not always work, and other approaches which respond more accurately to the origins of driving errors are necessary. A number of such approaches are described in the following sections. We explore both how interventions can respond to specific failures of reason – and also how we can

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[65] Avineri E. , Nudging Safer Road Behaviours, 2014

[66] Kahneman, D. and Klein, G. 2010. "Strategic decisions: When can you trust your gut?" *McKinsey Quarterly* March. http://www.mckinsey.com/insights/strategy/strategic_decisions_when_can_you_trust_your_gut

[67] Allsop, R. 2010. *The Effectiveness of Speed Cameras: A Review of Evidence*. London: RAC Foundation. http://www.racfoundation.org/assets/rac_foundation/content/downloadables/efficacy_of_speed_cameras_allsop_181110.pdf

exploit unconscious responses to improve driver behaviours. Most of these approaches broadly fall within the category of 'nudge' interventions which rely not upon bans or enforcement, but upon manipulations of the environment within which individuals make decisions. It is important to note that these approaches have in general not yet been rigorously tested – more research is required to understand what works in real world settings.

***Disruption: tackling thoughtless driving***

The problem of 'thoughtless' driving was identified above– situations in which unconscious System 1 processes become too dominant, and deliberative System 2 awareness and decision-making is dangerously side-lined. Two mechanisms were described. First, there are explicit moments in a driving journey when we need to be consciously engaged. In these situations stimuli from the road environment and from our vehicle can disrupt our thoughtlessness and bring us back to conscious thought. Focused stimuli can make us aware of potential hazards in our environment about which we should think, but may well not do so. Rumble strips on the approach to a roundabout can draw our attention to the impending junction; gateways which create a strong visual representation of entrance into a speed restriction zone can stimulate us to slow down; in-car alarms draw attention to the proximity of other vehicles when we are parking, or to freezing temperatures which require more cautious driving. Such nudges stimulate us to consider our behaviour, but do not demand that we alter it – as such they are a response to unintentional carelessness rather than to intentional behaviours.

Second condition of 'thoughtlessness' is the development of bad habits and ebbing of skills over time, as the impatient present self gains the upper hand over the moderating influence of the reflective future-oriented self. Again, a potential response is to disrupt such thoughtlessness, perhaps through refresher driver courses at regular intervals throughout a driving career. Compulsory refresher courses are likely to be considered an unacceptable extension of the 'nanny state'; but attendance at courses might be incentivised by discounts on car insurance[68]. Driver training is not automatically beneficial. Attendance on driver training courses can sometimes exacerbate undesirable over-confidence about driving skills and abilities, and even lead to increased risk-taking[69]: such a phenomenon is characteristic of yet another cognitive error, the 'confirmatory bias', whereby information is interpreted selectively to support pre-existing beliefs[70]. The purpose of refresher courses proposed here is explicitly to *disrupt* – to bring to awareness habitual and unconscious behaviours. This is not, in other words, the mere provision of information or addition of new skills: it is group discussions which enable reflection upon and revelation of the bad habits and unconscious biases which may underpin our driving behaviours[71]. The presence of others during such discussions may strengthen the meaningfulness of such reflections and any consequent commitments, creating the possibility of longer-lasting effects. Nonetheless there remains a caveat that deep-lying biases and attitudes are hard to shift.

***Avoiding distraction: system 2 on the right path***

Neurological explorations, as we have seen, have begun to quantify the extent to which distractions, such as mobile phone conversations, take away cognitive energies from our driving. How can we make sure our system 2 remains focused on the road – or at least does not focus elsewhere? Here there may be a role for straightforward bans and law enforcement. Given that evidence suggests that hands-free mobile conversations cause significant cognitive distraction and hence increased risk of accident, there is a strong case for extended legislation to ban such calls.

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[68] Avineri and Goodwin (2010) op. cit.

[69] Dorn, L. and Brown, B. 2003. "Making sense of invulnerability at work—a qualitative study of police drivers." *Safety Science* 41(10): 837–859

[70] Rabin, M. and Schrag, J. 1999. "First impressions matter: A model of confirmatory bias." *Quarterly Journal of Economics* 114(1): 37-82.

[71] Avineri and Goodwin (2010) op. cit.

Legislative bans, further, are more than simply elements in a cost/benefit jigsaw puzzle. They are not only a deterrent, but also a strong normative signal of the legitimacy or illegitimacy of given behaviours. The current legislative situation around mobile phone use in the UK, for instance, may create a paradoxical effect. Whilst handheld phone use creates both a physical and mental impairment to driving, a hands-free call cannot avoid mental impairment (and resulting gaze aversion) even if both hands remain fully engaged in the act of driving. By banning hand-held calls, but not hands-free calls, the latter are legitimised as safe – despite emerging evidence that they are not. The likelihood is that the incidence of hands-free calls increases[72].

Enforcement of this kind, as we have already observed, can be a blunt instrument. Extrinsic control through policing and punishment cannot be applied to every distracted behaviour. There is a broader challenge to establish an internalised understanding among motorists that driving when distracted is risky and inappropriate.

***Tackling biases and errors***

Unconscious errors and biases are not easily removed. Often, indeed, a powerful response, as discussed below, is to exploit these unconscious cognitive processes in order to push behaviour in the correct direction. Here we identify two sets of approaches to moderating unhelpful heuristics.

*Bridging the gap: making the future real*

We tend to underestimate likelihood and impact of an accident, and to struggle to imagine its impact (px above): we are misled by the availability heuristic; we have a failure of imagination about the future. Similar effects are described in the context of obesity, drug-taking and smoking, where those who eat too much, exercise too little, take drugs or smoke often fail to recognise the probability and full horror of the diseases which lie in store for their future self. Preventative work attempts to make the future real – images of diseased lungs, fat-riddled arteries and the physical impact of drug addiction bring the future into the present. Similar tactics have been frequently used to strengthen the imagination, and temper the optimism, of road users. Images in public campaigns against speeding have shown graphic representations of death or serious injury; occasionally there have been attempts to portray the psychological torment associated with causing death or serious injury through speeding[73]. Such messages make available, visually and shockingly, the future consequence of risky driving. This is more than simply an information campaign, for the information is framed in a particular way to nudge motorists towards a particular behaviour. Such interventions make sense in responding to reasoning failures, miscalculations, and failures of the imagination. Nonetheless there remain doubts about the effectiveness of such campaigns in reaching those drivers who are most likely to engage in risky behaviours. Again deeply-rooted biases are a barrier: those who hold a biased assumption that their speeds, while high, are reasonable compared to other drivers tend to discount such messages as targeted at others; even those who acknowledge the relevance of the messages may nonetheless continue to drive in a risky manner[74].

*Heading off visceral driving and lack of willpower*

Visceral driving is by its very nature difficult to interrupt when it is occurring – we are carried by the emotion or feeling. Instead interventions can seek to head off visceral driving before it occurs. One option is to make a commitment about our future behaviours while we are calm and dispassionate – to make, in other words a rational system 2 decision which can limit and control any future visceral impulses. The most obvious example of pre-commitment strategies is in the context of drink-driving.

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[72] World Health Organization 2011 op. cit.

[73] Royal Society for the Prevention of Accidents. 2011. *A history of road safety campaigns: Drink drive, seatbelts and speeding campaigns.* http://www.rospa.com/roadsafety/info/campaigns.pdf

[74] Walton, D. and McKeown, P. 2001. "Drivers' biased perceptions of speed and safety campaign messages." *Accident Analysis and Prevention* 33: 629–640.

We can commit, before going out for the evening, not to drink at all. This firm prior commitment becomes a resource upon which to lean in order to avoid temptations; its power is still stronger if the commitment is made in the presence of others[75]. The idea of a designated non-drinking driver exploits this social pressure.

In a similar vein strategies can be developed to deal with emotional or pressured situations before they occur. The response to being tailgated by another driver can thus be pre-planned and rational – maintaining a constant speed or pulling over – rather than emotional. To avoid pressured driving when late we could simply leave adequate time to arrive at our destination (including factoring in delays). In this case our failure to allow enough time for a journey is itself typical of a further well-documented cognitive bias, the 'planning fallacy', which describes people's tendency to be over-optimistic about the time a project or task will take, despite having experience of previous and similar failures to meet a timetable[76].

***Changing norms and cultures***

Changing norms and cultures around driving is challenging and complex. Three types of intervention are briefly described here. First, as we have observed, laws and law enforcement can send strong signals about what is appropriate behaviour. In some cases the need for external enforcement may ebb as behaviours become internalised as the right thing to do.

Second, interventions have addressed directly our biased beliefs about the behaviours of others – beliefs which we may invoke to justify our own risky behaviours or our refusal to engage with safety messages. Two interventions in the US state of Montana made use of a 'social norms' approach to increase seatbelt use and to reduce drink-driving among young adults[77]. In both cases initial research indicated that drivers considerably over-estimated the prevalence of risky behaviours amongst their peers; in both cases media campaigns were introduced which sought to convey the real prevalence of these behaviours. Media messages emphasised that non-risky behaviours were the norm: the central message in the drink-driving intervention was "MOST of Us Don't Drink and Drive"; other messages made the same point with statistics ("MOST Montana Young Adults [4 out of 5] Don't Drink and Drive"), or highlighted the strategies which the majority of people used to avoid drink-driving, such as taking taxis or using a designated driver system. In both studies a significant reduction in risky behaviours was reported by participants. Social norm approaches have been similarly successful in other contexts, such as improving the likelihood that taxpayers will pay taxes which are due[78]. Such interventions, of course, only have impact where the majority of individuals are indeed pursuing the desired behavior.

Third, shame has been explored as a tool to deter risky driving behaviours. The Mayor of Bogota employed mime artists to ridicule both pedestrians and drivers who committed road traffic violations[79]. There have been numerous instances in the UK where drivers who broke the speed limit outside schools have been subjected to an immediate interview by the school pupils about their

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[75] Avineri and Goodwin (2010) op. cit.

[76] Buehler, R., Griffin, D. and Peetz, J. 2010. "The Planning Fallacy: Cognitive, Motivational, and Social Origins." *Advances In Experimental Social Psychology* 43: 1-62

[77] Linkenbach, J. and Perkins, H. 2003. "Most of Us Wear Seatbelts: The Process and Outcomes of a 3-Year Statewide Adult Seatbelt Campaign in Montana." Paper presented at The National Conference on the Social Norms Model, Boston, MA, July 17; Linkenbach, J. and Perkins, H. 2005. *Montana's MOST of Us Don't Drink and Drive Campaign. A Social Norms Strategy to Reduce Impaired Driving Among 21-34-Year-Olds*. U.S. Department of Transportation, National Highway Traffic Safety Administration. http://www.nhtsa.gov/people/injury/alcohol/SocialNorms_Strategy/

[78] Hallsworth, M., List, J., Metcalfe, R. and Vlaev, I. 2014. *The Behavioralist As Tax Collector: Using Natural Field Experiments to Enhance Tax Compliance* (NBER Working Paper No. 20007). Cambridge, MA: NBER

[79] Caballero, M. 2004. "Academic turns city into a social experiment." *Harvard University Gazette*. 11 March.

behaviour[80]. Anecdotal reports suggest that such interventions have immediate impact upon the offending motorists; it is not clear, however, whether there is long-term behavioural change.

The Colombian mime artists and the UK schoolchildren share another beneficial property. Interventions are more likely to have impact if they attract our attention and have obvious relevance to our behaviours – if they are, in other words, 'salient'[81]. In both these cases the interventions are highly salient: they follow swiftly on from the transgressions, are implemented at the site of the transgression, and are likely to be highly memorable.

Fourth, there are attempts to re-socialise driving. We have observed that drivers can be bereft of the social cues which we usually take for granted when we interact with others; at an extreme we may begin to forget that the 'other' in these anonymous interactions is a fellow human. Reducing the atomised nature of the driving experience might, in principle, encourage more pro-social driving. In 2013 the New Zealand Transport Agency, for instance, launched Drive Social, an ambitious campaign to "fundamentally change the way New Zealanders think about the road and the people they share the road with."[82] The campaign sought to reorient driving as a social rather individual activity: central to the strategy was a website where motorists might encounter those who used the same road as 'real' people; similarly it has been proposed that cyclists should wear personalised clothing which nudges other road users to perceive them as human beings, not as objects in the generic category of 'cyclist' – an example slogan is "I am someone's mum."[83] The meetings between speeding drivers and schoolchildren following a speeding violation humanises the driving experience still further – the potential victim is present and embodies the potential dangers of risky driving.

Such strategies attempt to create some sense of the other road user as human. But there remains an absence of social cues as we use the road. Researchers are beginning to explore whether technology might replicate these cues. Emerging research, for instance, suggests that the creation of computerised avatars of other drivers may have some effect on driver behaviours, perhaps through creating some subconscious sense of the social presence of the other[84]. Such research remains in its infancy.

***Exploiting the unconscious: environmental nudges***

Road safety engineers have been effectively using 'nudge' techniques for a considerable time[85]. Road design features such as gateways, textured and coloured road surfaces, road markings and particular types of sign subtly change our perceptions of our environment, and consequently may cause us to alter our behaviours. Such interventions tend to operate at the system 1 level, manipulating our swift and unconscious decision-making processes. Precisely because the effects derive from an effect on our unconscious system, such interventions have relevance both to intentional risk-taking and unintentional carelessness.

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[80] For instance, Britten, N. 2010. "Speeding drivers face grilling from primary schoolchildren." *The Telegraph*. 2 July. http://www.telegraph.co.uk/motoring/news/7868549/Speeding-drivers-face-grilling-from-primary-schoolchildren.html

[81] Dolan, P., Hallsworth, M., Halpern, D., King, D. and Vlaev, I. 2010. *MINDSPACE: Influencing behaviour through public policy*. London: Cabinet Office / Institute for Government.

[82] New Zealand Transport Agency. 2013. *New campaign asks Kiwis to think of the road as a social network*. http://www.nzta.govt.nz/about/media/releases/2457/news.html

[83] Lill, J. 2014. "Bike group Cycle releases personalised cycling jerseys to improve driver attitudes on the nation's roads." *The Australian*. June 5. http://www.theaustralian.com.au/news/bike-group-cycle-releases-personalised-cycling-jerseys-to-improve-driver-attitudes-on-the-nations-roads/story-e6frg6n6-1226943131442?nk=2be763364f612b7eaf2c239d0133db9a

[84] Rakotonirainy, A., Feller, F., and Haworth, N. 2008. op. cit.

[85] Avineri and Goodwin (2010) op. cit.

Several interventions, for instance, manipulate our visual perceptions to encourage safer driving. In a much-cited example the city authority in Chicago sought to reduce accidents at a dangerous curve on the shores of Lake Michigan by painting a series of white stripes on the road surface, perpendicular to the direction of travel. The space between each stripe became progressively narrower as the curve become closer, a visual effect which creates an illusion of increasing speed and which in principle encourages drivers to slow. The measure is reported to have reduced accidents by one third[86]. A similar approach has been attempted in the UK, where trees were planted at decreasing intervals on the approaches to several Norfolk villages: the intended effect is again the illusion of increasing speed, and also an 'avenue' effect whereby the proximity of the trees might create some perception of narrowing. Early studies suggest favourable impacts on drivers' speeds[87]. White lines painted on the edges of rural roads can also create a perception of a narrower roadway, which in turn nudges drivers towards reducing their speeds.

Visual nudges can be applied to pedestrians too. The information at a typical traffic-light-aided pedestrian crossing – in other words, the red and green figures indicating when it is safe to cross – is displayed on the opposite side of the road. Recent designs have instead located this information above the push button on the pedestrians' side of the road; crucially the device is so placed as to nudge pedestrians' gaze toward the approaching traffic, thus encouraging them to check the safety of crossing themselves[88].

Road design can appeal to other aspects of our unconscious processing. Vehicle-activated roadside displays which flash up our speed, or indicate with a happy or sad face whether we are keeping to the speed limit, may be more likely to draw our attention to the speed limit than a static sign. In addition, they create a conscious and salient target – they focus our attention on lowering our displayed speed to the speed limit; or we try to make the sad face happy. Such targets can be surprisingly powerful. In an infamous example, the etching of black housefly in the centre of each urinal in the men's toilets at a Dutch airport improved accuracy and tidiness to a significant extent[89].

## VI. Automated Autos

No policy environment is static, and road safety will be significantly affected by technical advance, not least the increasing intelligence of the vehicle itself. Yet surprisingly little is known about the impact of that these advances might have on driver behaviour and the risks they choose to take.

Government ministers have been enthusiastic supporters of the development of "driverless" cars. One minister has stated simply that: *"driverless cars are the future"*[90], and the Department for Transport's 2015 *"Pathway to Driverless Cars"*[91] described how the technology will allow *"people to be more productive, and offer greater mobility to a wider range of people than ever before"*[92], suggesting that for the first time they could be: *"reading a book, surfing the web, watching a film, or just chatting*

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[86] Thaler and Sunstein 2008 op. cit.; Thaler, R. and Sunstein, C. 2010. "Measuring the LSD effect: 36 percent improvement." *Nudge blog* posted 11 January. http://nudges.org/?s=lake+shore+drive

[87] King, B. and Chapman, S. 2010. *Taking on the Rural Road Safety Challenge*. London: Department for Transport

[88] Avineri 2014. Op. cit.

[89] Thaler and Sunstein 2008 op. cit.

[90] Department for Transport, Department for Business, Innovation & Skills *UK to lead the development of driverless car technology* Press Release, 11 February 2015

[91] Department for Transport *The pathway to driverless cars: Summary report and action plan* February 2015

[92] ibid, p6

*face to face with other passengers"*[93]. It seems, however, that public support for driverless cars is concentrated on the potential for driving whilst impaired[94].

There is, of course, a challenging path between the current situation and the fully automated car, reminiscent of the April Fool's joke that Britain must make a phased transition to driving on the right, with commercial vehicles and buses the first to make the switch.But the transition to the driverless car is already underway, with cars gradually assuming responsibility for important safety decisions, whilst other technologies create new driver distractions to fill the gap. Active braking systems (ABS) have now become well established, and production cars can be specified with parking assistance and lane assistance, and adaptive cruise control (ACC).

***Risk-Seeking Behaviour***

Automation carries with it the risk of substitution behaviour. Thrill-seeking is a human trait, and a reduction in control over driving, and the associated challenges, could generate risk-seeking in other ways as drivers adapt to the new environment. This has, for example, been seen with Adaptive Cruise Control.

Rejecting the concept of *"robot cars"* Audi has been developing *"piloted driving",* in which the driver chooses when to hand over control, so that*: "the feeling of freedom, and the fun of sporty driving will be maintained – because there is a choice"*[95].

***Regulatory Challenge***

The pace of change of technology will challenge existing systems of regulation, based on driver observation and financial penalties. Whilst the use of handheld mobile telephones is illegal, the use of hands free telephones is not. They have very similar effects on driver response times, but the current system of regulation can deal with the former, but not the later. The growth of wearable technology within the *"internet of things"* will shift far more activity into the category of those that are undetectable by observation. The majority of adults now use a smartphone, and new communications methods such as instant messaging, are beginning to replace traditional voice calls and text messaging. The proportion of adults using data services on mobile phones grew by eight percentage points in the year to Q1 2014, to 57%[96], and in 2013 people spent twice as much time using mobile messaging as making voice calls[97].

Of course, many cars now feature touch-screen or voice-activated integrated audio, navigation and communication systems, and will be internet-enabled in order to feed back systems data. Research has, however, suggested that voice-activated systems may actually place a greater cognitive demand on drivers than their predecessors[98]. On the other hand manufacturers and software developers claim

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[93] ibid, p12

[94] Payre W, Cestac J, Delhomme P *Intention to use a fully automated car: Attitudes and a priori acceptability* Transportation Research Part F, 27(2014), 252-263

[95] Audi *Audi piloted driving* 04 Journal http://www.audi.com/com/brand/en/vorsprung_durch_technik/content/2014/10/piloted-driving.html Accessed 3 March 2015

[96] OFCOM *The communications market 2014: 5 – Telecoms and Networks* OFCOM, London (2014) *p346* *http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr14/UK_5.pdf* Downloaded 11 March 2015

[97] ibid. p351

[98] AAA *Measuring cognitive distraction in the automobile II: Assessing in-vehicle voice-based interactive technologies.* AAA Foundation for Traffic Safety, Washington DC, October 2014 *https://www.aaafoundation.org/sites/default/files/Cog%20Distraction%20Phase%202%20FINAL%20FTS%20FORMAT_0.pdf* Downloaded 11 March 2015

that some wearable technologies, such as the head-up display *"Google Glass"* could alert drivers to signs of drowsiness or impending road dangers[99].

*The human condition: Cognitive Load and Technical Ability*

In managing the transition to the driverless car it is important to differentiate automated systems by their impact on the driver's decision process. In the case of Autonomous Emergency Braking (AEB), for example, the technology is able to react better and faster than the human, and is simply addressing the gap between the reaction required and our more limited technical ability to react. Thatcham Research has estimated that financial incentives to encourage the uptake of AEB on new cars could avoid more than 12,000 casualties between 2015 and 2025[100]. It is also now available on about one quarter of new cars, and does benefit from a financial incentive as cars with AEB attract reduced insurance premiums compared to those without. The Group Rating Manager at Thatcham Research[101] has claimed that: *"Low-speed bumps and shunts account for three-quarters of all collisions, typically at speeds of under 20mph in 'city' driving scenarios. This is where AEB systems perform best, avoiding crashes of up to 15mph and reducing the severity of those up to 25mph. This includes collisions at junctions, roundabouts and in stop-start traffic where one car runs into the back of another"*[102].

Other advances, however, run the risk of imposing new cognitive loads, which may have the net effect of reducing driver response times or fuelling over-confidence. The House of Commons Transport Committee has warned that:

> *"Policy makers will need to be alert to the possibility of unintended consequences, such as changes in behaviour that lead to drivers becoming too dependent on technology and not being alert enough to take control of a vehicle when they need to. Research can help policy makers understand such effects and how best to guard against them"*[103].

***Haphazard haptics***

A promising area of development has been systems that provide touch-based feedback to the driver, known as haptics[104]. To date, most feedback to drivers has used either sight or sound, through visual displays and audible alarms. In order to broaden the range of feedback, and avoid diverting the senses that are most engaged in driving safely, haptic can provide feedback through the driver's body, just as most mobile phones now include a vibrating alert function.

Recent analysis has tried to measure the impact of feedback systems on drivers' cognitive workload. Kahneman describes this workload as the *"investment of attention"* that is required when driving[105]. There is only so much attention that can be safely invested. The question is whether haptic systems, by easing the load on the driver's eyes and ears, also reduce the share of attention taken by the targeted aspect of driver behaviour. Research into eco-driving initiatives, conducted in a driving simulator in

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[99] EIU *Wearable tech: Scourge or safety new* Economist Intelligence Unit/Cadillac (2014) http://cadillacaimhigh.economist.com/wp-content/uploads/2014/10/Wearable-tech-English.pdf Downloaded 11 March 2015

[100] House of Commons Transport Committee *Motoring of the Future* Eight report of Session 2014-15, HC 429, February 2015, p12 http://www.publications.parliament.uk/pa/cm201415/cmselect/cmtran/429/429.pdf Downloaded 11 March 2015

[101] A UK research centre funded by the motor insurance industry

[102] Thatcham Research *Cut the cost of car insurance – Choose AEB* News Release, February 2015 http://www.thatcham.org/news-and-events/news-and-press-releases-reader/items/cut-the-cost-of-car-insurance-choose-aeb Accessed online 11 March 2015

[103] ibid p13

[104] Hurst, N *"Can you feel me know? The sensational rise of haptic interfaces"* Wired, 13th February 2013 http://www.wired.com/2013/02/haptics/ Accessed online 18th March 2015

[105] Kahneman, D *Thinking fast and slow* Penguin Books, London (2012), p413

Leeds, has suggested that they do. It also found, however, that haptic systems are less effective than visual feedback through on-board displays[106].

In the Leeds study the haptic feedback came through the accelerator pedal, which adjusted either the force required to pass an appropriate point in relation to eco-driving algorithms, or a step-change in stiffness beyond the currently appropriate point. Similar systems have, however, been used for other driving goals, including collision avoidance, with feedback through the brake pedal[107], or through the steering wheel[108]. Satellite navigation can now use vibration turn-alerts, through the handlebars of a motorbike , and lane assist systems can send alerts to a driver through their steering wheel or seat when they stray outside of their lane. Jaguar-Land Rover is reported to be developing a "Bike Sense" system within which the driver's seat will provide a "tap on the shoulder" on the appropriate side if a cycle is passing[109].

The RAC has warned that: *"While all these new devices are meant to make us safer behind the wheel and provide fewer distractions, until we learn how to use them properly to benefit us – extracting the maximum from the technology – we're going to encounter some teething problems along the way"*.

We run the risk that new technologies generate more ways to provide more information to drivers, rather than reduce the workload involved in coping with existing levels of information. Confronted with information overload we tend to take sometimes dangerous shortcuts in decision-making.

As the RAC has acknowledged: *"Ultimately, the relentless pace of development will make sure we're safer and more secure on the roads. But until that point, we have to remember it is we who are in control of the vehicle, and interacting with even the smallest ancillary system can take our eye off the ball"*[110].

At present technological progress is pursuing multiple, and sometimes conflicting, goals; preventing harm to the driver and their vehicle, protecting other road users, making in-car entertainment and communication systems more capable and less intrusive, and promoting environmentally-friendly driving. Once the driverless car becomes reality these conflicts will also be managed by the technology. In the interim there is substantial scope for new forms of human error. The Government's "roadmap" towards driverless technology should account of this, given the significant advances that have been made in the incorporation of human behaviour into policy making.

## VII. Conclusion

An analysis of driving safety within the context of behavioural economics provides useful suggestions for policy.

Firstly, as the protection of the driver and other vehicle occupants continues to improve much more needs to be done to make the risks to other road users more salient. Strategies that target emotions, and that allow drivers to better visualise their future self, are best able to tackle the impatience and aggression of the present self.

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[106] Jamson SL, et al *Drivers' ability to learn eco-driving skills; effects on fuel efficient and safe driving behaviour* Transportation Res. Part C (2015) http://dx.doi.org/10.1016/j.trc.2015.02.004

[107] Lee et al *Driver sensitivity to brake pulse duration and magnitude* Ergonomics 50, 828-836

[108] Jensen MP, et al *A customizable automotive steering system with a haptic feedback control strategy for collision avoidance notification* IEEE Transactions on vehicular technology, Nov 2011, 60:9, 4208-4216

[109] Sparkes, M *New Jaguar 'taps driver on the shoulder' to warn of cyclists* Daily Telegraph 20th January 2015 http://www.telegraph.co.uk/technology/11354765/New-Jaguar-taps-driver-on-shoulder-to-warn-of-cyclists.html Accessed online 18th March 2015

[110] RAC *Future car technology: What to expect* Blog post 16th August 2012 http://www.rac.co.uk/community/blog/rac-blog/august-2012/technology-of-tomorrow-communicating-with-your-ca Accessed online 18th March 2015

Secondly, the transition to the driverless car needs to be carefully considered for its behavioural impacts. Drivers may:

- increase their risk-seeking activities in order to maintain their sense of autonomy
- engage more in distractive activities in order to maintain overall cognitive activity
- develop greater territorial "cocoon" feelings, that affect their responses to other road users intrusion into their space
- Suffer from increased cognitive loads due to the availability of in-car information, whether by visual, sound, or haptic systems

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