

Driverless Cars and the Sacred Cow Problem

Abstract

The promoters of driverless cars have demonstrated remarkable progress in their ability to program their vehicles to respond with *extreme deference* to pedestrians, cyclists, and cars with human drivers. Such programming confers *sacred cow* status on all road users *not* in self-driving vehicles. The developers of autonomous vehicles acknowledge the need for new road safety rules to accommodate these revolutionary vehicles on public highways. But would-be regulators have yet to propose a set of rules that would allow these sacred cows to move about freely in dense urban areas without creating a state of deferential paralysis for those in autonomous vehicles.

Driverless cars

Driverless cars, it is frequently proclaimed, are products of a disruptive technology. Extraordinary progress is now being made in the development of the artificial intelligence algorithms on which they are based. The nature of the disruptive outcomes that might follow from the “success” of this technology is much less clear. There are competing, highly selective, visions of the futures that it might shape. Let us begin with the “optimistic” vision of Google’s Sergey Brin; it appears remarkably like Uber without the driver:

“... if cars could drive themselves, there would be no need for most people to own them. A fleet of vehicles could operate as a personalized public-transportation system, picking people up and dropping them off independently, waiting at parking lots between calls. ... Streets would clear, highways shrink, parking lots turn to parkland.”¹

This vision has been elaborated in Ted talks by Sebastian Thrun², one of the Google car’s principal designers, and Chris Urmson the head of the project³. Both stress safety as the car’s principal selling point, asserting that most accidents are caused by driver error, and that the Google car will be able to eliminate almost all of them. Urmson provides video evidence of the car’s remarkable ability to respond deferentially to other road users, even cars and cyclists running red lights. Both proclaim the freedom it will bring to those unable to drive: the young, the very old, those with physical disabilities, especially the blind, and those otherwise legally disqualified.

Urmson makes a distinction between Tesla’s approach of progressively developing driver assistance until full autonomy is achieved, and Google’s insistence on the importance of its vehicles being fully autonomous. He argues that as driver assistance improves, drivers trust it too much and are unready to intervene when

¹ Bilger, B. (2013) ‘Auto-Correct: Has the self-driving car at last arrived?’ *The New Yorker*, November 25, available at www.newyorker.com/magazine/2013/11/25/auto-correct

² https://www.ted.com/talks/sebastian_thrun_google_s_driverless_car#t-8300

³ https://www.ted.com/talks/chris_urmson_how_a_driverless_car_sees_the_road?language=en

needed in emergencies: an argument supported by a recently reported fatal accident involving a Tesla operating in autopilot mode⁴.

Starting from here

Before considering possible impediments to the achievement of Google's vision, let us look at the present state of road safety. The first thing to note is how much has changed over a relatively short period of time. Figure 1 illustrates the extraordinary 96% decrease in road accident deaths per kilometer driven in Great Britain between 1950 and 2012. How might Google cars perform in Great Britain's current road safety climate? Might they really achieve a further 90% reduction?

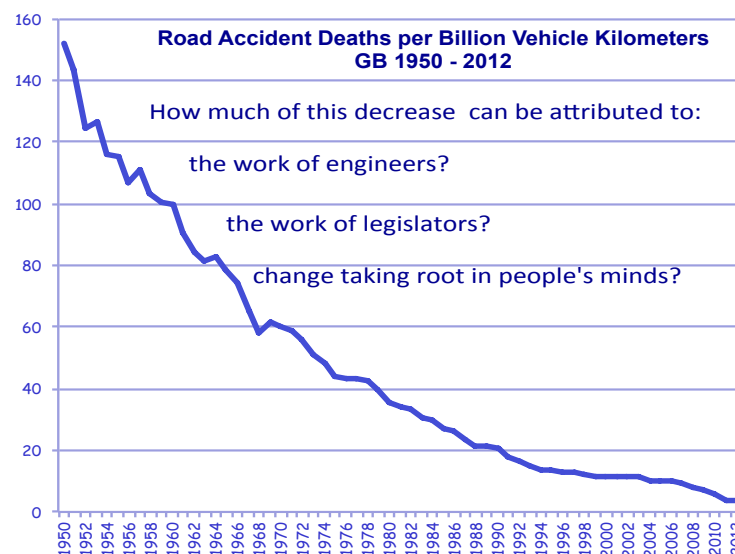


Figure 1. GB road accident death rates⁵

Figure 1 invites explanations for the decline displayed on the graph. Over this period *engineers* have equipped cars with better brakes and tires, more stable suspensions, crash protection in the form of seat belts, airbags, interior padding and crumple zones and, in recent years, with some of the precursors of autonomous cars such as pre-emptive braking. How much of the credit do they deserve? Legislators and regulators have also been busy with speed limits, alcohol limits, the prohibition of texting and the use of mobile phones while driving, and the development of vast numbers of regulations governing the design of almost every aspect of the road infrastructure and of the vehicles travelling on it.

The extremely modest effect of most of these safety interventions has been examined in some detail elsewhere.⁶ Here I offer but one example: Britain's 1983

⁴ <http://www.nytimes.com/2016/07/11/business/fatal-tesla-crash-draws-in-transportation-safety-board.html? r=0>

⁵ <http://www.john-adams.co.uk/2015/11/23/cycling-and-safety-change-must-take-root-in-peoples-minds/>

seat belt law. It represents a combined effort of engineers and regulators. The seat belt with its carefully calculated anchorage points and well tested webbing and buckle offers considerable protection in a crash. And its use, when required by the 1983 law, increased almost overnight from about 35% to 95%. With what result?

Figure 2 shows that the established downward trend prior to the law was interrupted by a plateau that lasted for eight years.

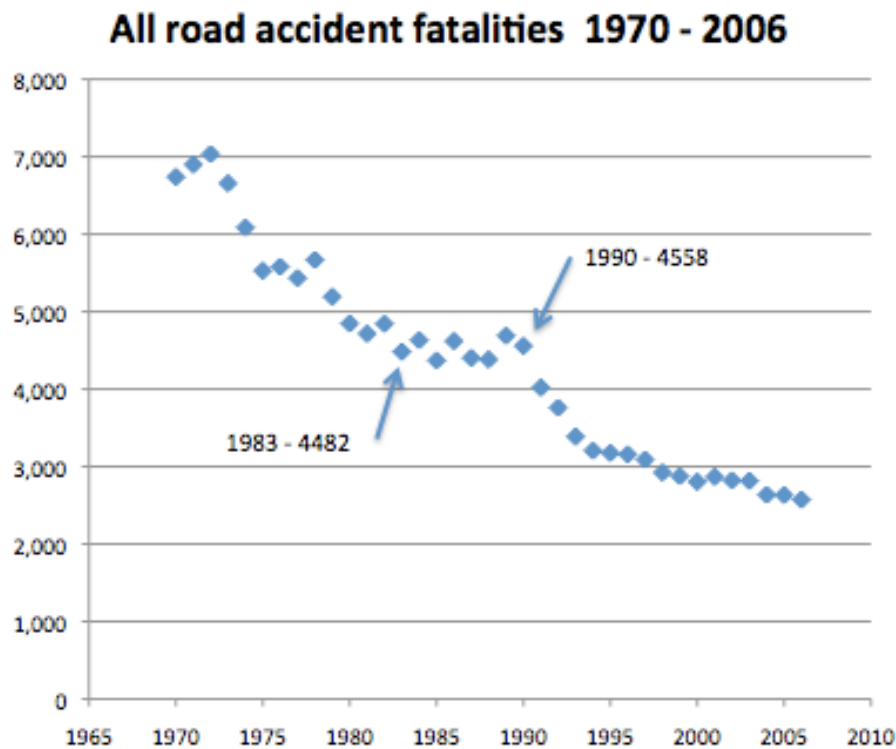


Figure 2. One effect of the seat belt law.⁷

Figure 3 suggests an explanation. The ratio of pedestrian and cyclists fatalities to car occupant fatalities, that stood at over 6:1 in the 1930s had fallen to less than 1:1 by the early 1970s and was continuing its decline until the year the seat belt law was introduced when it jumped by 25% before resuming its downward trend. It appears that there was a behavioural response to the work of the engineers and legislators that frustrated their intentions.

⁶ See for example: <http://www.john-adams.co.uk/2015/11/23/cycling-and-safety-change-must-take-root-in-peoples-minds/> and “Managing transport risks: what works?” Chapter in *Handbook of Risk Theory* https://www.amazon.co.uk/Handbook-Risk-Theory-Epistemology-Implications/dp/9400714327?ie=UTF8&keywords=risk%20theory%20handbook&qid=1433933564&ref=sr_1_1&s=books&sr=1-1, free copy here <http://john-adams.co.uk/wp-content/uploads/2010/12/Management-of-the-risks-of-transport2.pdf>

⁷ <http://www.john-adams.co.uk/2009/11/05/seat-belts-another-look-at-the-data/>

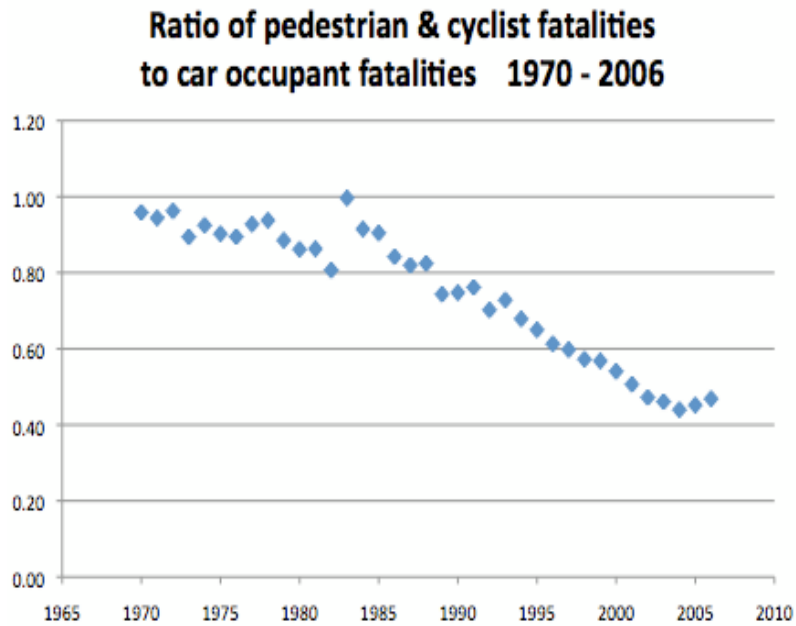


Figure 3. Another effect of the seat belt law⁸.

Figure 4 lends further support to the view that all the engineering and legal interventions listed above deserve an extremely modest share of the credit for the decline in fatalities displayed in Figure 1. It shows the correlation between the national road accident fatality rates per 100,000 vehicles for 129 countries plotted against the countries' scores on the United Nations Inequality-adjusted Human Development Index (IHDI)⁹.

⁸ <http://john-adams.co.uk/2009/11/05/seat-belts-another-look-at-the-data/>

⁹ Created by Mahbub-ul-Haq and Nobel Laureate Amartya Sen, the Inequality-Adjusted Human Development index is a composite of average longevity, education and income, adjusted for inequality - http://en.wikipedia.org/wiki/Human_Development_Index, see also Figure 7 in Adams, J. "Risk: mathematical **and** otherwise" *The Mathematics Enthusiast*, vol.12, no. 1&2, 2015

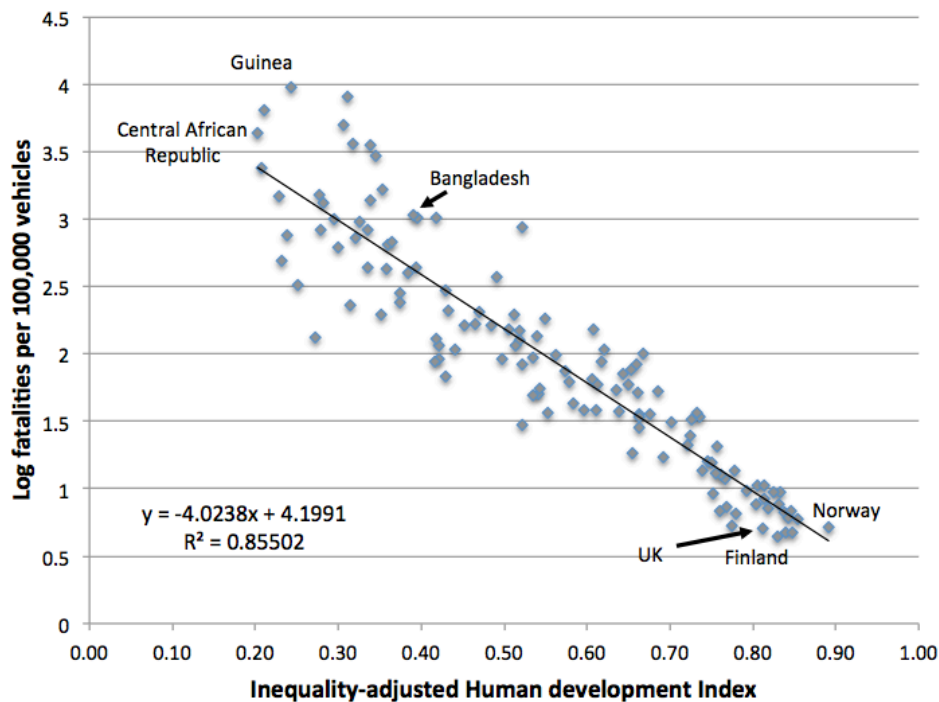


Figure 4. Development and road accident fatalities¹⁰

All of the countries toward the lower end of the trend line shown in Figure 4 have experienced declines over recent decades comparable to that shown for Britain in Figure 2. The safest country in Figure 4 is Finland, close to its neighbour Norway at the top of the human development scale. Guinea, close to the bottom of the development scale has a fatality score more than two thousand times higher than Finland's. Almost all of the developing countries toward the top end of the trend in Figure 4 have, on their statute books, almost all the road safety laws in force in Finland and Norway. Guinea, for example, has a national speed limit, an urban speed limit, a law against drinking and driving, motorcycle helmets laws for drivers and passengers, a national seatbelt law and a law banning the use of mobile phones while driving. The Central African Republic, bottom of the development scale, has the same, minus a law banning mobile phones, but plus compulsory use of seat belts in rear seats, and a national child restraint law¹¹. None of the countries toward the bottom of the development scale has a car manufacturing industry; they are achieving their extraordinary kill-rates per vehicle with modern imported vehicles with over 100 years of safety technology built into them. And the fact that they have inferior roads is unlikely to explain the enormous difference between countries at the top and countries at the bottom. Ruts and potholes are nature's speed bumps; they slow traffic and reduce the severity of the accidents that do occur. So what else is going on?

¹⁰ <http://www.john-adams.co.uk/2015/11/23/cycling-and-safety-change-must-take-root-in-peoples-minds/>

¹¹

http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/

Change must take root in people's minds

This brings us to the third question posed in Figure 1. This question was provoked by Harvard philosopher Michael Sandel's observation that "Change has to take root in people's minds before it can be legislated."¹² In 1975 in a paper entitled "The Scandinavian Myth" Laurence Ross presented some impressive support for this dictum. He looked at the effect of drink-drive legislation in Sweden¹³. Sweden had, at that time, the world's strictest laws governing drinking and driving: low permitted alcohol levels, strict enforcement, draconian penalties and low alcohol related fatality rates. It was held up to the rest of the world as an exemplar of what could be achieved through legislative intervention. But Ross found that the data did not support the myth; his interrupted-time-series analysis revealed no effect of the legislation on the relevant accident statistics. He noted that Sweden had a politically powerful temperance tradition and that drinking and driving had been widely viewed as a serious offence (if not a sin) before it was formally identified as such by legislators. He concluded that the law had ratified established public opinion, and was being obeyed before it was passed.

Figure 5 provides a more recent example from the United States of a phenomenon to which the Sandel dictum might also be applied. In 2010 the Insurance institute for Highway Safety published the results of a study that confounded their expectations. Four states, California, Louisiana, Minnesota and Washington, passed laws banning texting while driving – laws passed with the intention of reducing "distracted driving"¹⁴. These laws constituted natural experiments. Each state had on its borders other states that had not passed such laws, and these states served as controls against which the effects of the banning laws were measured. The reported result was: "texting bans don't reduce crashes; effects are slight crash increases." Figure 5 displays the result for California, measured against the control states of Arizona, Nevada and Oregon. This result, unexpected by the authors of the study, was described as a "perverse twist".

Apparently the change in the law was not accompanied by a change that had taken root in people's minds; or rather not the *desired* change. A law that was intended to decrease "distracted driving" appears to have increased it. The report's somewhat tentative conclusion: "clearly drivers did respond to the bans ... what they might have been doing was moving their phones down and out of sight when they texted, in recognition that what they were doing was illegal. This could exacerbate the risk of texting by taking drivers' eyes further from the road and for a longer time."

Instead of texting on the steering wheel where they could, sort of, keep track of what was happening on the road, they started doing it on their laps where the

¹² <http://www.theguardian.com/lifeandstyle/2013/apr/27/michael-sandel-this-much-i-know>

¹³ See *Risk* p.152 and H.L. Ross, The Scandinavian Myth: The Effectiveness of Drinking-and-Driving Legislation in Sweden and Norway, H. Laurence Ross, *The Journal of Legal Studies*, Vol. 4, No. 2 (Jun., 1975), pp. 285-310).

¹⁴ <http://www.iihs.org/iihs/news/desktopnews/texting-bans-dont-reduce-crashes-effects-are-slight-crash-increases>

offence could not be seen. A law intended to decrease distracted driving increased it. Change, supporting the legislation, had not taken place in people's minds.

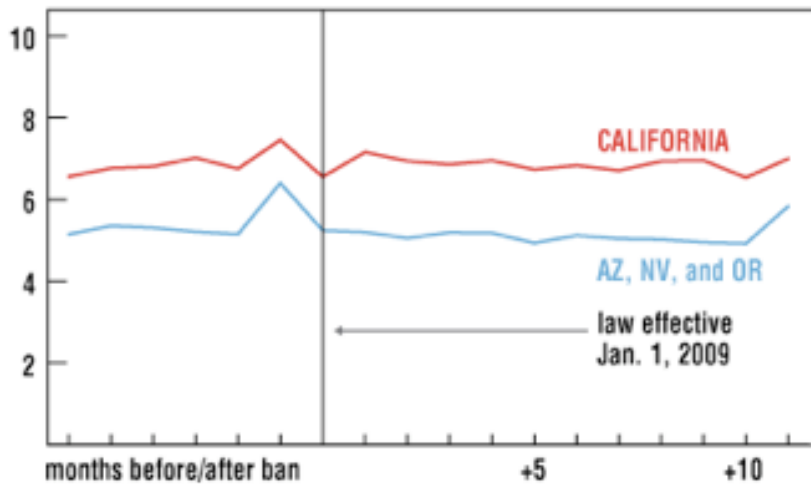


Figure 5. "California – Collision claims per 100 insured vehicle years, by month before and after texting law for all drivers, compared with Arizona, Nevada, and Oregon."

The Sandel dictum and the "perverse twist" illustrated by Figure 5 are consistent with the *Risk Compensation Hypothesis* set out in Figure 6. The model proposes that everyone has some propensity to take risks (the setting of the thermostat) that leads to risk-taking behaviour that leads, by definition, to "accidents": to take a risk is to do something that carries with it a probability (usually unknown) of an adverse outcome. It is through surviving accidents and learning from them, or seeing them on television, or being warned by mother, that we acquire our perception of what is safe or dangerous. The model proposes that when propensity and perception get out of balance there will be a behavioural response that seeks to restore the balance. Why do we take risks? There are rewards. And the magnitude of the reward influences propensity.

Safety measures that are perceived to reduce risk, in the absence of any change in propensity to take risk, as appears to have been the case with drivers wearing seat belts in Figures 2 and 3, and the texters in Figure 5, will lead to behaviour that seeks to restore the original perceived level of risk. This behaviour is well known to the insurance industry that calls it "moral hazard" – a rather judgmental term to apply to the actuary's observation that people with house contents insurance are less careful about locking-up, or that drivers drive less carefully when wearing a seat belt ¹⁵.

¹⁵ See - <http://www.john-adams.co.uk/?s=seat+belt>

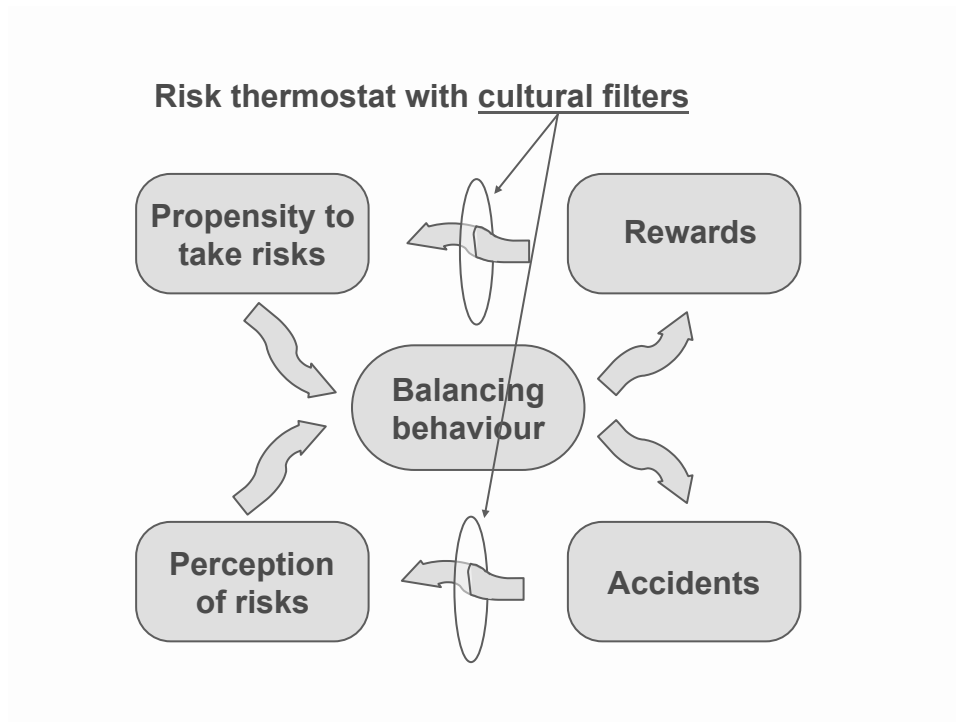


Figure 6. The Risk Thermostat¹⁶.

The model is fitted with cultural filters in acknowledgement of the cultural differences that exist on the roads in the countries displayed in Figure 4. Figure 7 displays the relationship between the coefficient of human inequality, used to adjust the indices in Figure 4. It suggests that an important aspect of the process of “development” is growing societal equality – societies in which people are wealthier, better educated and healthier, tend also to be more equal¹⁷.

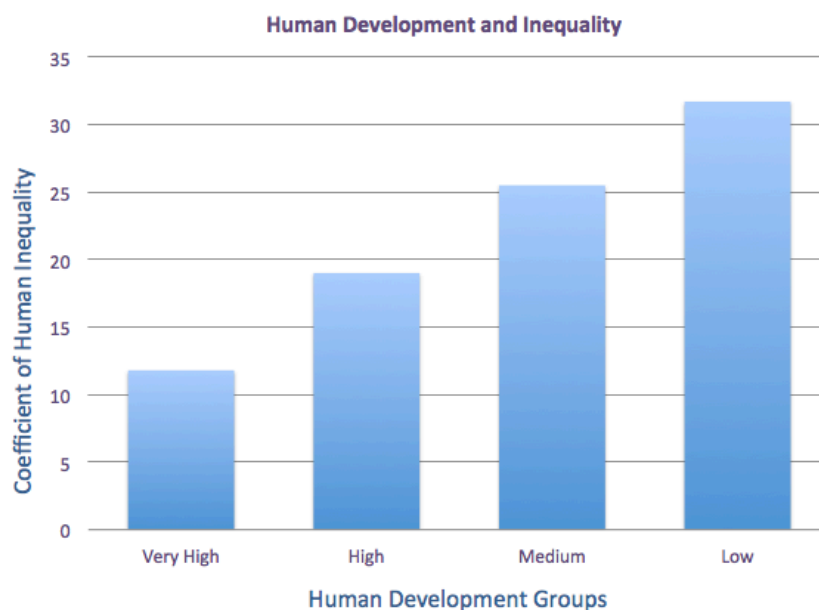


Figure 7. <http://hdr.undp.org/en/composite/IHDI>

¹⁶ J. Adams (1995) *Risk*, p.43.

¹⁷ Although in the developed world, in recent decades, becoming less so.

In countries at low levels of development cars are few in number and those who own them tend to drive with a disdain for the goats and chickens and “peasants” who cross their path. In such countries effective egalitarian road safety campaigns are conspicuous by their absence. Road users in more developed, more equal, societies tend to behave with more consideration of others on the road. They also tend to be more risk averse.¹⁸ The filters through which the risks and rewards of crossing the road or driving along it clearly lead to enormous differences between rich and poor societies in road user behaviour.

How does this relate to the future prospects of driverless cars?

In all the accounts that I can find of the development of driverless cars, and the safety with which they might operate, attention is called to the impressive ability of their programmers to ensure the safety of all those on the road *not* in driverless cars. The “driver” of the driverless car will not, cannot, frustrate the intentions of the engineers and regulators because they, in effect, *are* the driver. The rapidly improving collision-prevention algorithms governing the braking, accelerating and steering of driverless cars, will have to be approved by legislators and regulators before they will be allowed on the road. The possibility of risk compensation by drivers discussed above will be eliminated. But what response might we expect from those still on the road but not in driverless cars? How might they respond to their newly conferred invulnerability?

Clearly one should expect different responses in Norway and the Central African Republic – they have different cultural filters. In highly unequal countries at the CAR end of the development range most of those killed in road accidents are vulnerable road users – children, pedestrians, cyclists. Their poverty renders them fatalistic in the face of the numerous threats to their health and safety that they are daily compelled to endure, at the mercy of the disdain of the motorised wealthy.

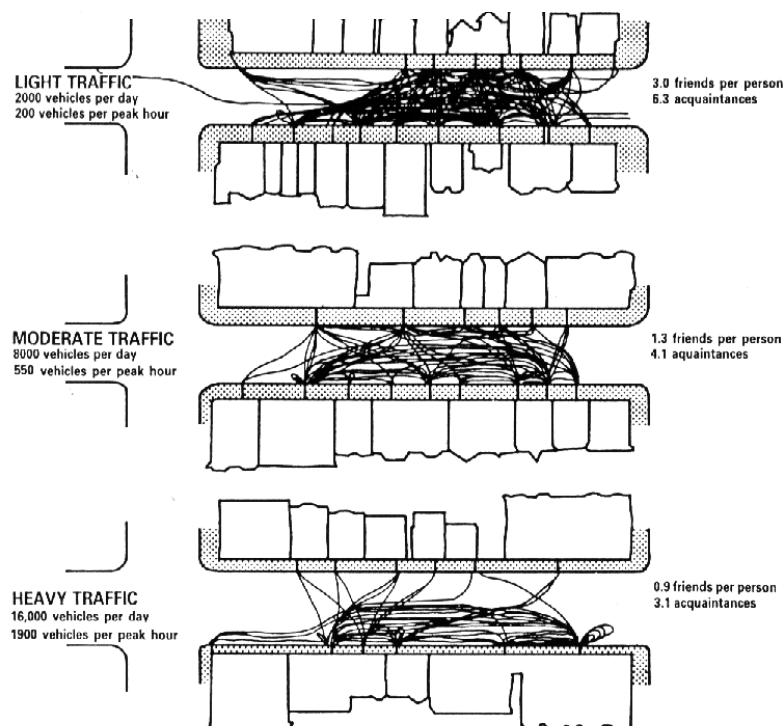
It is difficult to imagine fleets of driverless cars being adopted in the Central African Republic; their programmed egalitarianism would threaten the privilege of the car owning elite. But in the thought experiment that imposes them on the roads of the teeming slums of any major third world city it is difficult to imagine why the previously vulnerable would not take advantage of their newly conferred invulnerability; the driverless cars would be would be unable to move.

What might one expect at the developed end of the development distributions displayed in Figures 4 and 7? Why would vulnerable road users respond any differently to the invulnerability conferred upon them? Figure 8, taken from a famous study some years ago of three streets in San Francisco, illustrates the dramatic retreat of pedestrians in the face of the increasing threat of traffic. If the threat were removed – programmed out – might people once again get to know their neighbours across the road, at the gross inconvenience of those in cars wanting

¹⁸ In 1971 in England 80% of 7 and 8 year old children got to school unaccompanied by an adult. By 1990 this had dropped to 9%, and the principal reason parents gave for denying their children the freedom that they had enjoyed as children was fear of traffic.

to travel along it. Might young children once again be allowed to travel to school on their own, perhaps playing the game of “stop the car” en route?

Figure 8. Three streets in San Francisco¹⁹



What is the current state of research into the problems that unautomated road users might pose for driverless cars? The Gateway Project funded by Innovate UK (the UK Government’s innovation agency) offers an incomplete list of important things they confess to not knowing:

- “Whether pedestrian knowledge that the vehicle is autonomous impacts their risk perception and behaviour, positively or negatively?
- How pedestrians will react when attempting to cross a road in front of an approaching autonomous vehicle?
- Will crossing behaviour be any different from the interaction with normal vehicles? And if so, how is the behaviour affected by the difference in every aspect between the normal vehicle and the autonomous vehicle?”²⁰

Those confessing this ignorance are confident that answers will be found. They describe their endeavours as “a technology driven project that aims to demonstrate the safe and efficient integration of sophisticated automated transport systems into complex real world smart city environments.”

Conclusion

Promoters of autonomous vehicles have demonstrated convincingly that they can be programmed to defer to obstacles in their path – be they other vehicles, cyclists,

¹⁹ From *Liveable Streets* by Donald Appleyard, University of California Press, 1981.

²⁰ <http://fseg.gre.ac.uk/fire/gateway.html>

pedestrians, children, cats, dogs, or trees and other roadside objects. But this alone is not sufficient to enable the Google vision briefly outlined at the beginning of this essay. To provide the safe liberation of those unable to drive extolled by the proponents of autonomous vehicles - to enable Uber without drivers - these vehicles will have to be able to offer a door-to-door service in urban areas. In such areas autonomous vehicles will encounter many *sacred cows*, other road users to which they have been programmed to defer. The rapidly expanding literature on autonomous vehicles acknowledges that the legal framework covering roads, vehicles, and their users, will require substantial revision to accommodate the safe introduction of vehicles without drivers. But the problem of deferential paralysis has yet to be addressed.

What changes in the rules of the road would have to take place to permit the efficient sharing of the road between driverless cars and invulnerable human sacred cows? And what changes would have to take root in the minds of these sacred cows before such changes could be legislated? Perhaps research might begin in a part of the world already living with the problem. (see Figure 9).

Figure 9²¹

Culturally programmed drivers deferring to a small herd of sacred cows: result - deferential paralysis



“Vehicles and traffic come to a grinding halt in India every day when the cow decides to cross. In such instances, the cow is supreme.”

²¹ From Traffic and the sacred cow in India
<http://beforeitsnews.com/opinion-liberal/2015/09/traffic-and-the-sacred-cow-in-india-2513650.html>