Driving – An Information Management Cognitive Approach: Solving the inattentive human 'autopilot' problem by effective communication and information management. Part 1 of 2. [Indentifying the problems]

By

David C. Westlake, MSc; C.Eng; M.I.Mech.E; M.I.E&T.

Retired Lecturer from:-

Information Management Systems Cognate Group,

School of Computing,

Faculty of Engineering and Computing,

Edinburgh Napier University,

Edinburgh.UK

Abstract [Part 1 & 2]

This research paper in two parts, applies information management [IM] system theory to human intelligence [HI], driving. The literature review establishes reasons why many but not all inexpert drivers have poor driving information management skills.

The study researches how driving experts apply IM, finding statistically significant results confirming use of verbal or non-verbal commentary reasoning to fully apply our working memory. Verbal and non verbal concurrent verbalisation [commentary] is found to contribute significantly in formulating, executing and updating a driving plan that can handle driving conditions. The research finds learning superior driving information management techniques is not without its problems.

Expert IM driving applies observation techniques that accommodate vision saccades and fixations plus additional skills too, thus creating a synergy between man and machine. The study describes how non-expert drivers may learn to apply better IM.

These information management techniques also set up, maintains and improve the communication channels across the open system boundaries and solves the problem of the 'inattentive autopilot' driver that is not applying effective information management to driving. Effective driving information management achieves proactive driving; inattentive 'autopilot' or other poor techniques leads only to dangerously reactive driving response.

The study finds that a proper learning and application process involving the conscious and unconscious working memory, not just penalty points and fines, is vital to achieve continued driving improvement.

Keywords:

Driving cognitively

Information Management System

Human intelligence

Concurrent verbalisation

Highlights:

- Confirms expert driver agreement on verbal and non-verbal reasoning.
- As a means of achieving effective driving information management
- Applying our working memory to the best effect

Glossary of Terms:

ITS Intelligent Transport System

IM Information Management

IS Information System

ICT Information Communications Technology

DSS Decision Support System

ESS Expert Support System

ABS Antilock Braking System

TCS Traction Control System or sometimes identified as

SCS Stability Control System or

DSC Dynamic stability control system

WM Working Memory

DAS Driver attention assist system

CCT Cognitive Computing technology

HI Human Intelligence

AI Artificial [neural network] Intelligence

FL Fuzzy logic

CTL Conventional temporal logic software

HCI Human Computer Interface

GP Generic Programming

CASE tool: Computer Aided Software Engineering [workbench]

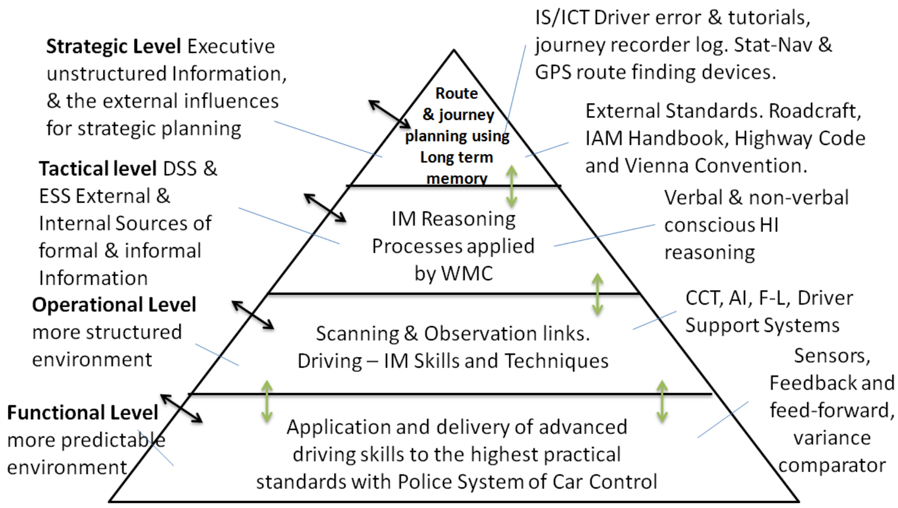
1.0 Introduction

This research paper is in two parts. Part 1 identifies the problems and part 2 investigates the solutions, studying the role of effective communication in improving driving information management. The variation in road traffic conditions, inclement weather, types of hazards and adverse driving behaviour of many but not all motorists combine together to make driving a complex and sometimes difficult task. This study applies information management theory. It identifies communication is taking place internally and externally across system boundaries in order to properly deal with the different driving conditions. Properly handling all driving conditions requires a strategic, tactical and operational approach. The information management and information systems including the human driver must have fully functional parts to provide management control of the driving plan implementation. The major open system features are shown below [Fig 1 & Fig 2]. The system parts are significantly linked together for control purposes.

To deal with road traffic conditions, effective information management is required at the strategic, tactical and operational levels for every journey. For example in difficult winter driving conditions during or after heavy snow some 'answers' are required. Is the trip really necessary? What hills or route should I avoid? What route is passable or most suitable? Is the data reliable? Is my vehicle and myself properly equipped for the trip and what emergency plans and equipment is in place? A driving IM taxonomy sets out these interrelated parts and information management hierarchy. Westlake, (2015).

Fig 1

Driving – An Information Management Taxonomy



With acknowledgments to Anthony (1965) and the later addition Davis (1974).

Adapted from Wysocki. & Young, J; (1990). p 30-32. Roadcraft (2013, Appendix, 'GDE Matrix' - Goals for Driver education).

Source: Fig 3, Westlake, (2015).

Anthony viewed all the parts of his management taxonomy significantly linked together for control purposes. The parts are linked together by effective channels of communication.

Communication theory was significantly defined and developed in a seminal paper that enabled the growth of information systems we know of today. The paper contained important counterintuitive ideas. The more random the content appeared in the data stream, the more information was contained within the message flow. (Shannon, 1948). The more random the data content the more processing has to take place to convert data into meaningful information.

Information is the meaningful content of a message. It is encoded using a system of symbols, transmitted via a channel, and decoded again on receipt. The quality of the transmission can be degraded by many reasons, making the message content eventually indecipherable. The full meaning intended by the sender needs to be fully comprehended by the receiver rapidly enough when driving to handle the prevailing driving conditions. Thus the transmission's integrity, quantity and quality is vital in conveying the complexity of the message content. (Westlake, 2015).

Unfortunately in system theory terms, effective communication is not always taking place between the various sub-system components and the driving information processing and decision making is not always satisfactory.

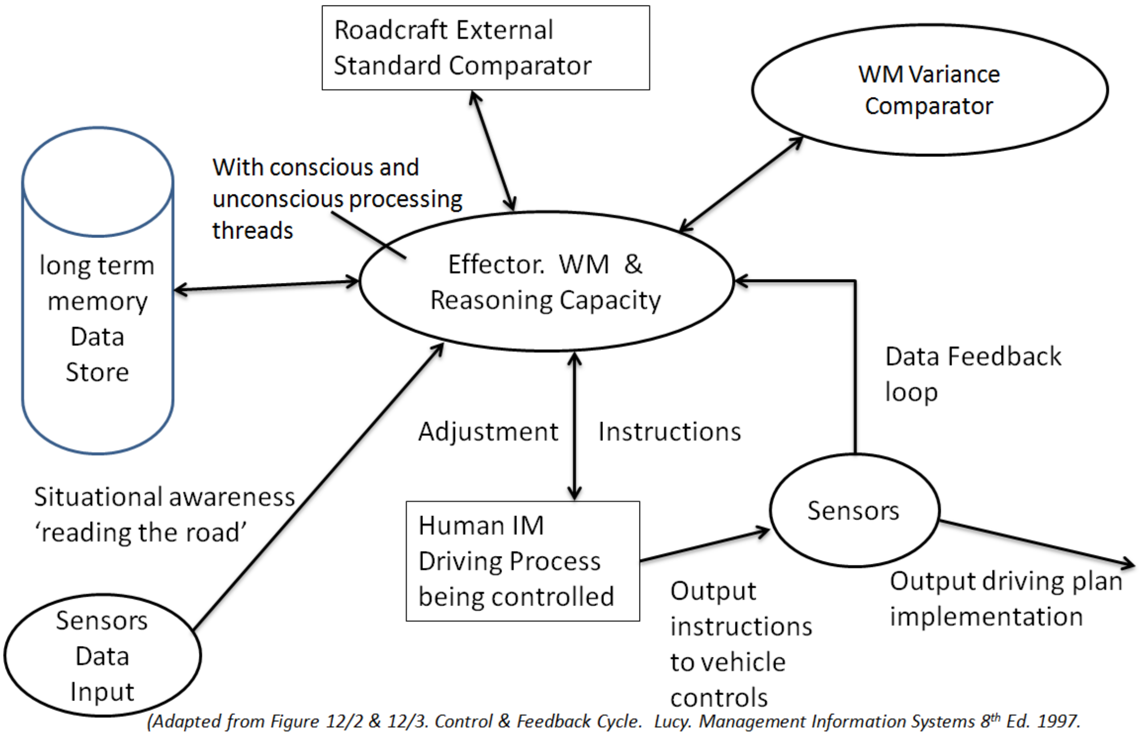
The sentient human mind uses experience, intuition and hopefully rational decision making to develop 'answers' to these typical questions posed in the 2nd paragraph in the introduction, often using highly imperfect or dubious data. It is difficult to envisage computer cognitive technology-based autonomous driving systems being sufficiently capable to accommodate this flexible, highly uncertain and often very imperfect strategic decision making. They may work more effectively at the operational and functional level. (Westlake, (2015). Based on information in the public domain outlining how they could possibly work, these fully autonomous driving systems will input the destination address and work out a route using preset selectable criteria, like a satellite navigation system does today. Unless they are 'sentient' (Westlake, (2015) it is unlikely valid strategic thinking will have taken place which the human mind is capable of conducting.

2.0 Nature of the human driving information management problem

The basic human intelligence driving system components and prime communication channels are as follows (Fig 5, Westlake, (2015):-

Fig 2

HI Driving Information Management System



(Adapted from Figure 12/2 & 12/3. Control & Feedback Cycle. Lucy. Management Information Systems 8th Ed. 1997. Publisher Letts Educational)

For a computer cognitive technology [CCT] system the parts can be connected by a significant number of 'closely coupled' inter-communication channels. This complex configuration can be subject to disruption. Each communication channel between the system parts must be fully maintained. (Westlake, (2015). However a human intelligence [HI] system is not closely coupled in a similar deterministic sense and may not perform as desired or expected for a variety of complex reasons. Human intelligence based communication channels may not be sufficiently dependable. These communication channels require 'active maintenance' in order to control the different driving conditions. This research study investigates how this 'active maintenance' can be achieved. It can be effectively applied in sentient computer cognitive technology driving systems as well. (Westlake, (2015).

2.1 Literature Review

> A former Chief Examiner of the I.A.M. described
>
> "…driving a vehicle as a problem solving activity, and the four key skills of driving – concentration, observation, anticipation and planning – are intellectual skills that we co-ordinate with our handling skills to deal with the problems that confront us on the road……". (Lunn 1996, page 25-26).

This raises important issues about the capability of human intelligence in dealing with different driving conditions. Why is this particular type of intellectual problem solving activity not carried out as well as it should be? How can improved information management and information systems address this poor performance?

Expert police and advanced drivers apply improved observation and anticipation skills, types of commentary supporting reasoning and further vehicle control techniques. These combined techniques make the overall performance greater than the sum of the system parts, producing a synergy.

2.1.1 Role of Human Information Processing in driving

We take, use and give 'Information' as part of our everyday lives, taking its processing and management for granted. With poor driving, it is obvious it is being processed very badly as a driver's mind is not properly working on the task. Furthermore the human driver may well believe they are driving properly when in fact they may not be for the driving conditions or situation. Effective computer cognitive driving technology can significantly assist in solving this problem in human driving (Westlake, (2015).

Take two common occurrences. 'Tail-Gating' or use of excessive speed for the road traffic conditions in a stream of traffic on a typical motorway, dual carriageway or ordinary road when the 'two-second' rule is not being applied. Both examples indicate a lack of objective observation and hazard perception.

The Scottish traffic Police Driving School advised the writer that it's just not about hazard perception. It is more about dangerous driving. Drivers believe they are safe at these distances and can react if something happens when in fact they can't, being unaware or forgetting stopping distances. That's a primary cause of collision. (Inspector Darren Foulds Personal Communication at a meeting at the Police College at Tullyallen Castle and exchange of email 25th March 2013). All vehicles and drivers are not the same but all must obey the ‘laws of physics’. Vehicles have different stopping distances according to the driving conditions and vehicles fitted with the latest technology can stop in shorter distances than shown in the Highway Code. However some vehicles may take even longer to stop than expected in the Highway Code (Rule 126).

What can be done to avoid ‘tailgating’ and other similar dangerous practices? An answer within the ‘laws of physics’, has been available for some while.

If the vehicle ahead slows, **Active Cruise Control** [ACC] keeps you at an appropriate distance behind it by automatically slowing your car. When the vehicle ahead picks up pace again, ACC returns you to your desired speed, maintaining a safe gap at all times. (BMW, 2003). The technology is slow in being adopted but its prevalence is increasing in recent ‘new-build’ vehicles.

However unless such systems are made a mandatory ‘retrofit’ which is technically difficult and very unlikely in the ‘used car market’, an immediate solution to poor driving, properly involving our minds, is therefore still urgently needed.

Applying system theory, system feedback is not being comprehended properly by the driver then acted upon correctly. The feedback is not effective. The system process isn’t modified or enhanced to bring the process back under proper control. Also, an effective external standard or ‘comparator’ is not being properly applied. This problem is not new, is stubbornly difficult to solve and yet as this writer argues in part 2, (Westlake, (2015), effective practical solutions are available.

2.1.2 Stubborn Problem to Solve – initial gathering of some evidence

There are many reasons, some of which may be more obvious than others to identify and practically solve. Much research work has and is being done by many people and university research teams. Many research papers have in-depth detailed statistical analysis about the parameters studied. Several applicable examples from this large body of published work are very informative.

One researcher found that the driver’s understanding of the task developed with experience and novice drivers do not show this sensitivity to road complexity nor observe hazards as well (Underwood, 2007). Another team of researchers observed aggressive driving was related to personality variables, such as hostility, sensation seeking, and competitiveness. (Harris et al., 2008). Sometimes the findings are counter intuitive, finding high-aggression drivers did not underestimate risk. (Davis et al.,1998). Others investigated more issues about measuring drivers frustration, finding it decreased awareness of potential danger. (Lee, 2010).

Interestingly a researcher found the use of information is adversely affected by time pressure caused by traffic congestion. (Stern, 1999). Drivers could have an inflated opinion of their own hazard perception skills. (Horswill et al., 2004). Later the research team found that experienced drivers underperformed in hazard perception and had little proper appreciation of their skill level. The study also found that for effective training, positive feedback was important and both experienced and expert police drivers benefitted from it. (Horswill et al., 2012). The former point about hazard perception is disturbing, the latter point about positive feedback much more encouraging.

Experienced but inexpert drivers may become complacent, suffering boredom when processing information largely at the automatic level. Desiring a higher arousal level, drivers are searching for thrills, with fast or careless driving at minimal safety margins. (Michon, 1978). There is not a correlation between explicit driving ability that recognises the need for both skill and appropriate caution working together. Instead drivers are resorting to achieving increasing task demand satisfaction by speeding, mistakenly believing driving skills alone are sufficient. (Harre et al., 2007).

3.2 Growth in the Information Burden, road layout complexity and Vehicle Performance.

As part of the literature review a brief illustrative empirical study gathers evidence of the many changes that have taken place over circa the last 130 years.

3.2.1 Automobile introduction & road layout complexity

The information processing requirements placed upon drivers have increased substantially. During the period from the late Victorian / early Edwardian era, broadly from when the automobile was first introduced circa 1885 it has developed to the highly designed, built and equipped vehicles of today. Anecdotal evidence in pictures and current experience illustrates the huge changes since the early 20th C, in both ‘Street Furniture’, road layout [hence information] and vehicle appearance [hence capability].

Fig 3 Photo Princes Street Edinburgh circa 1920

Princes Street from the West (c1920) A view looking eastwards along Princes Street shows the Royal Scottish Academy building on the right and beyond that the towers of the Scott Monument and the Balmoral Hotel. There are an open-top tram and old-fashioned cars on the road and in the foreground a cart with two large baskets on it. There are many people walking past the canopied shops.

Photograph by Inglis, Alexander Adam from the Edinburgh and Scottish Collection © With permission of The Edinburgh City Libraries www.capitalcollections.org.uk

3.2.2Modern Street Furniture and Information Processing Overload

Progressively more and more street furniture has become 'built-in' to our road layout in an endeavour to make our roads safer.

Fig 4 *Princes Street, Edinburgh, Scotland, looking east, June 2014.© David Westlake*

By June 2014, a similar view of Princes Street and its environs has become a much more complex area. It has one-way traffic management systems, yellow-box junctions, segregation of vehicle types with bus lanes and mixed traffic streams with the reintroduction of trams. These are all combined with higher traffic speeds and densities. Drivers need to commit being in the right position, speed and gear etc with effective information management in order to negotiate this junction by taking appropriate action some distance before it, within it and on exit from it. They are then faced with similar complexities at the next junctions they come to. This is typical of many major junctions and traffic management schemes in the UK.

3.3 More Modern Trends

Monderman (2008) spent a considerable part of his life as a Road Traffic Engineer investigating and providing radical innovative solutions many of which questioned the perceived wisdom prevailing at the time and were counterintuitive.

> “..........His maxim was: "If you treat drivers like idiots, they act as idiots. Never treat anyone in the public realm as an idiot, always assume they have intelligence..........." cited from Obituary, The Times (London) 11th January 2008.

Adding a little uncertainty by introducing mini-roundabouts at junctions for example, makes drivers apply their intelligence to think, plan and react thus interact more safely and effectively. This is an improvement along the trend-line towards the above objective, applying the ideas developed by Monderman (ibid).

The trend is towards ‘open-plan’ road layouts where there is more of a mix between pedestrian and car traffic instead of segregation. This makes drivers engage their minds with the hazards around them to avoid collisions. There is a downside. This trend towards these new layouts and the low running noise from trams and electric-hybrid cars, is making it difficult for the current generation of guide dogs to assist the visually or audibly impaired. Solving the problem of vehicles and cyclists coming into contact by larger modification of traffic junctions, separating areas of potential conflict with better cycle lanes, will take much longer to implement.

In 2011 the UK Transport Minister ordered a review of ‘street furniture’ that some people think has become excessive. This will take time to complete and implement changes. Have all these information management problems become so excessive, beyond our level of human intelligence to effectively comprehend sufficiently well?

3.4 Role of Human Intelligence for Information Processing & Reaction Times in Driving

More evidence has been forthcoming, adding further perspectives and a new dimension which needs addressing. A study in the journal '*Intelligence'* has published more recent research about declining reaction times and the associated declining intelligence in the population. Both reaction times and general intelligence IQ are important for driving. The latter is important in order to process the necessary information properly, the former to put car control properly into practice to deal with prevailing driving conditions.

It has been shown simple visual reaction time measures correlate substantially with measures of general intelligence with research showing a decline of IQ of fourteen points since Victorian times. (Woodley, M.A et al., 2013). The study argues that mean male and female respectively reaction times of 183-187 milliseconds [ms] in the Victorian era compare equivalently to modern mean reaction times of 250-277 ms respectively. The study found the differences were statistically significant. Furthermore, age was not a significant factor. Woodley M.A. et al., (ibid.)

The above research article is extensive and well referenced. If however comparison is made only with Victorian times rather than more recent data available, its findings are dependent upon the accuracy of 'reaction times' measured by Galton (1889). Accessing [electronic copy retrieved 25th July 2013] the proceedings of the British Association for the Advancement of Science describes the measuring apparatus. Its developer, Galton (ibid) maintained the reading graduation scale of his pendulum device was to hundredths of a second. There is no diagram of the apparatus, built in London. Thus whilst no doubt very innovative and acceptable then, it is not as reliable as the timekeeping methods now available. At risk of stating the obvious, it is not possible to replicate these original Victorian results. The research findings have been questioned by leading experts and an extensive technical rebuttal published, (Woodley, M.A et al., 2014) who stand by their research work. More recently published research claims that since the 1920's each generation is becoming more intelligent than the last with a net IQ gain of circa 3.7 points per generation by the age of 11 already due to the 'Flynn effect', but not in this latest study, the 'Matthew' effect that could also apply (Staff et al; 2014). Can only one or are both Woodley (ibid) and Staff (ibid) research teams be right?

Each team is working from a different base, measuring different data to define changes in human IQ. The 'Flynn effect' (Flynn, 1994) assesses the influence of smaller families, better education and environmental complexity. The 'Matthew effect' (Merton, 1968) measures the influence of accumulated economic advantage, prosperity etc that is not evenly distributed, impacting the ability to eat well and follow intellectually stimulating activities. Thus both research teams are arguably assessing the impact on IQ of changes in 'nature and nurture' of different strata and different generations of society over time. Thus plausibly both research terms could be right. Human intelligence however you try and measure it is not the same across all the human population.

The socially disadvantaged in terms of 'nature and nurture' including the important formative early years of education and roles that stimulate IQ, could be finding driving information processing more difficult. This should be compared with the socially advantaged who have benefitted from nature and nurture's bounty and extremely good fortune passed down from successive generations thus being blessed with better IQ. More research is needed to answer these complex questions and issues but some further revealing research has already been done.

The teenage mind still needs to develop sufficient information processing capability to fully master all the driving skills. (Isler et al., 2008). The latest generation of young drivers have been brought up with video games, smart-phones, mini-pads, text messaging and the like. This equipment requires manual dexterity, limited use of our range of intelligence and some effective reactions. Unfortunately these devices are becoming decision support systems [DSS] and expert systems [ES] focusing on 'output'. This is not fully engaging the reasoning power of our minds in the data processing of 'how' and 'why', not stimulating or challenging our intelligence. Thus to off-set these trends, young drivers need to continue to develop further reasoning power and training in order to drive to the highest standard they are capable. Compared to younger drivers, older drivers had a more efficient scanning routine and safer vehicle control. (Lee, 2010). Arguably however, the generations or two before this latest one also has a problem. Not brought up with technology at their fingertips from being youngsters, some are also likely to have difficulties associated with slowed reaction times, but not be aware of it, limiting the ability to deal with different driving conditions. Thus some sections of the driving community arguably have a problem. Even if the strength of association between reaction times and human IQ is rejected by some researchers as being too weak, the measured decline in reaction times alone is still worrying in the driving context.

3.5. Initial findings

3.5.1 Some implications

The above prima facie evidence supports the premise that solving the driving task problem identified by Lunn (1996) involving use of our intelligence and coordination (reaction) capabilities is becoming progressively more difficult for some drivers to do. Information processing requirements appear to have increased and to some, our processing capacity apparently has diminished. The driving information systems must deal with the lowest common denominator of human intelligence abilities so not to exclude anyone from proper comprehension. Developments in decision support systems and expert system ‘driver-assist’ technology are involved in making up for this deficiency but only part of the way towards filling the requirements. Indeed they have several basic weaknesses and problems with human intelligence, driver-assist and current computer cognitive technology driving systems have been identified. (Westlake 2015). This needs solving in order to deal with current and foreseeable driving conditions.

3.5.2 Evaluation of non expert drivers. The distribution of driving skills

Experienced but inexpert drivers requiring an ‘adrenalin-fix’ of increased arousal levels may encourage poor driving. (Michon, 1978). There is not a correlation between explicit driving ability and the need for appropriate caution (Harre, et al., 2007) and drivers could have an inflated opinion of their own hazard perception skills. (Horswill et al., 2004). Only when combined with enhanced safety perception awareness, do driving skills reduce accidents. (Summer et al., 2006).

There is a further problem about mistaken perceptions many non-expert drivers have about their own ‘above average’ level of competence thus leading to complacency. Arguably the common perception is the widely held conviction that non–expert drivers believe they are better than the average of the driving population.

It appears all too plausible how such a claim can be made and the supporting ‘reason’ not to question any doubts about its validity. This error arises because of a lack of understanding of mathematics.

First the problem:-

> “.....Ask any 100 drivers how good they are and over 90 will tell you they are above average. This is of course a mathematical impossibility – they are fooling themselves......” (Soothern, J; 2009, IAM Driving Handbook, p ‘Epilogue’).

Some or even many drivers may be and probably are fooling themselves about their abilities, but not for the mathematical reasons claimed above. It is not mathematically impossible for many but not all to be better than their population average. The main reasons explaining why this is so is as follows:-

The distribution of driving skills is actually a complex topic. A Driver Skill Inventory of 28 items was developed for assessing a Driver’s view of their skill and safety. (Lajunen, et al., Table 1, 1995). It is difficult to statistically measure the magnitude of poor or good driving in the population. Do you measure ‘skills’ or technical reasons for accidents to make such an assessment and are the statistical distributions different for such measures? [They are.] How can the bulk of a particular population be better than its own average? If the frequency distribution of skills is ‘normally distributed’ across a population then the distribution of skills is symmetrical about the arithmetical mean. It thus cannot be different from the median or mode along with other technical qualifying features. If however the distribution is not ‘normal’ but for example skewed on the good skill-side it will have an arithmetical mean, with its median and mode frequency values on that good side of the mean. Then the assertion that a large majority of drivers being better than average is mathematically possible. (Yeomans, 1968, page 115, fig 44). According to a study of driving skills this is indeed so, the distribution of driving skills is not normal and the claim they are above average is mathematically legitimate. (Elvik, R. 2013). There are further technical reasons that have been established by research that are explained and discussed in Elvik’s paper. Thus the LR evidence needs to be gathered impartially and present an overall balanced, not biased level of substantiation.

4.0 Initial Conclusions – the situation is not ‘all-bad’: it needs to be better.

Reviewing the video content of several hours of advanced driving training material (Gilbert, ibid) shows they contain very few examples of dangerous or very poor driving. Some examples are of on-coming cyclists passing through a red traffic light, a cyclist approaching on the wrong side of the road round a blind bend, an approaching motorcyclist that is executing a high speed ‘wheelie’ with the front wheel well off the road surface. An aggressively speeding motorist approaching from behind well into a 30mph speed limit in a village and a motorist not giving way at a mini roundabout crossing in front and a good number of motorists probably exceeding the speed limit or ‘tailgating’ in lane 1, 2 or 3 on sections of motorway and dual carriageway. A ‘white van’ driver cuts sharply in front of Gilbert’s car in lane 1 braking hard then decides after all not to exit a motorway moving back into lane 1, just by the exit. (Gilbert, ibid, DVD sets 1, 2 & 3). Not everyone on the DVD recordings are bad, mad or beyond redemption at the ‘poor ability’ tail of the driving skill distribution curve. Many are considerate, driving defensively or driving reasonably well, clustered around the mean and towards the ‘good’ side of the skills distribution.

This does not mean there is no need for improvement. Many drivers are not driving with due care and attention or are actually driving dangerously for accidents to occur. The 90% of accidents are due to driver error. (Malone, citing Huber, 2013). Studies have shown that accident statistics are very complex, have a Binomial-Poisson statistical distribution and there is an asymmetric relationship between driving and safety skills, with over-confidence in driving skills leading to risky driving especially if not buffered by safety skills. Enhanced skills on their own cause complacency and increased risk of accidents. (Summer et al., 2006).

In answer to the above complex issues, explaining how better human driving information management can be achieved is researched in part 2 (Westlake,2015) of this study.

David Westlake

MSc; P. Dip.B.A.(Edin); C.Eng; M.I.Mech.E; M.I.E&T; M.C.M.I; FHCA; M.I.A.M.

March, 2015

5.0 Acknowledgments

John Graham and his staff at the Police Foundation. The Roadcraft (2013), Chairman Inspector Darren Foulds, Scottish Police Driving School and his Expert Practitioners panel members, The Class 1 Police drivers and Police Driving instructors, both serving and retired, for the time and effort in answering the research questionnaire. Peter Rodger, IAM Chief Examiner and the staff of the IAM. My helpful colleagues at Edinburgh Napier University. Dr Lisa Dorn, Reader in Driver Behaviour, Driving Research Group, Cranfield University for her advice. Heather Owen for encouragement and support.

6.0 Funding for research

No funding or research grant has been made available to accomplish this work.

7.0 Conflict of Interest Statement

The author reports no conflict of interest related to this work.

8.0 Bibliography & References

Anderson, A; 'Culture lab: Corridors of the mind' New Scientist Vol. 221 # 2959, 8th March 2014, p 46-47. Reed Business Information Ltd. Citing Dehaene, S; (2014). Book title 'Consciousness and the Brain: Deciphering how the brain codes our thoughts'. Viking Press.

Authie, C.E; Mestre, D.R; article 'Optokinetic nystagmus is elicited by curvilinear optic flow during hight speed curve driving'. Journal Vision Research Vol 51 (2011) page 1791-1800. : Elsevier Ltd.

Automobile Association. The Highway Code. (2007). [Reprint 2011] Pub. AA Publishing & its extract of The Highway Code Pub. TSO. [Pages 11-29].

Bertozzi, M; Broggi, A; Fascioli, A; (2000). 'Vision-based Intelligent Vehicles:State of the art and perspectives'. Journal of Robotics and Autonomous systems. Vol. 32. P1-6. Elsevier Science B.V.

Biever, C; (10th August 2013), Article 'Machines come to Life'. New Scientist. No 2929. page 8-9, citied Dominey et al. : Reed Business Information Ltd.

Boehm, B.W; (1988). 'A Spiral Model of Software Development and Enhancement'. Journal Computing Vol 21, issue 5, p 61-72. : IEEE.

Bohr, Bernd (2013) cited in 'News' article 'Driverless cars 20 years away'. Journal of the Institution of Mechanical Engineers. Vol 26 No 5. 'Professional Engineering', page 5. May 2013.

Blake, R; Brascamo, J; Heeger, D; (2014). 'Can binocular Rivalry reveal neural correlates of consciousness?'. Philosophical Transactions of The Royal Society, B; Vol:369, # 1641 'Abstract'. The Royal Society.

BMW . German HQ International Web Site (2013) Retrieved 25th July 2013. http://www.bmw.com/com/en/insights/technology/connecteddrive/2010/safety/

B.M.W. Approved Used Car website Retrieved 25th July 2013 from http://www.approved.bmw.co.uk/bmwuk/bmwauc/detailed_search/

BMW (2013). A video is at http://www.driving.co.uk/features/bmw/5-series/on-the-public-roads-in-bmw-s-driverless-car/12100, showing the 'driverless' BMW 5 series, driving itself down the autobahn. Retrieved again 25th July 2013.

BMW (2003). Adapted from BMW Magazine Summer 2003 Page 39, 40 & 34 for BMW (GB) Ltd Cedar Communications Ltd

Burgess, K. (2013, May 13th) "……..Dutch Style Safety on Britain's Roads……". Cited from The Transport Research Laboratory site at Bracknell. *The Times*. http://www.thetimes.co.uk/tto/news/uk/article3763069.ece

Cao, S; Liu, Y; 'Concurrent processing of vehicle lane keeping and speech comprehension tasks' Journal Accident Analysis and Prevention (2013). Vol. 59 p 46-54. Elsevier Ltd.

Campbell, M; Egerstedt, M; How, J.P; Murray, R.M; 'Autonomous driving in urban environments: approaches, lessons and challenges. Philosophical Transactions of The Royal Society. (2010). Vol 368, p 4649- 4672. : The Royal Society.

Coutton-Jean, C; Mestre, D; Goulon, C; Bootsma, R.J; article 'The role of edge lines in curve driving', Journal: Transportation Research Part F, Vol 12 (2009) page 483-493. Elsevier Ltd.

Crick, F. C; Koch, C; (2005). 'What is the function of the claustrum?' Philosophical Transactions of The Royal Society', B. Vol: 360. P1271-1279. The Royal Society.

Crundall, D and Underwood, G (1997) 'Concurrent Verbalisation During Drivers' Visual Search and Hazard Perception'. Journal: Traffic and Transport Psychology: theory and application. Proceedings: Chapter 14 page 122-135. Accessed by British Library document supply service on 29th November 2013.

Crundall, D; Andrews, B; van Loon, E; Chapman, P; (2010) 'Commentary training improves responsiveness to hazards in a driving simulator', Journal of Accident Analysis and Prevention Vol. 42 Page 2117-2124). Elsevier Science Direct.

Colom, R., Martinez, A., Shih, P.C., Santacreu, J., (2010, September) ‘Intelligence, working memory, and multitasking performance’ Journal ‘Intelligence’ Volume 38 page 543-551. : Elsevier.

Davis, R; Dorn, Lisa; Glendon, I; Hoyes, T; Matthews, G; Taylor, R; (1998, March) ‘Driver Stress and Performance on a driving Simulator. The Journal of Human Factors and Ergonomics Society. Vol. 40 no. 1 page 136-149.

Dodonova, Y.A., Dodonov, Y.S., (2012, November) ‘Faster on easy items, more accurate on difficult ones: Cognitive ability and performance on a task of varying difficulty’ Journal ‘Intelligence’ Volume 41 page 1-10. : Elsevier.

Dorn, L; Barker, D; (2005), ‘The effects on driver training on simulated driving performance’, Journal Accident Analysis & Prevention Volume 37 issue 1 p 63-69. Elsevier.

Dorn, L; Brown, B; (2003), ‘Making sense of invulnerability at work- a qualitative study of police drivers’, Journal Safety Science. Volume 41, issue 10 p 837-859. Elsevier.

Edwards, C; (2014, July) article ‘Obey the clock’, E & T Magazine, Volume 9, Issue 6, page 74-77. : The Institution of Engineering & Technology.

Edwards, C; (2014). ‘Car safety with a digital dashboard’, E & T Magazine, Volume 9 Issue 10, page 60-64. The Institution of Engineering & Technology

Elvik, R; (2013). P 302. ‘Can it be true that most drivers are safer than the average driver? Journal: Accident Analysis and Prevention’. Vol. 59, p 301-308. Elsevier.

Evans, B.J.W. (2001), *Dyslexia and Vision,* London and Philadelphia. Whurr s.

Flynn, J.R; (1984). The mean IQ of Americans: Psychological Bulletin. Vol 95. Issue 1. P 29-51. American Psychological Association.

Fogarty, A.W ; Lui, C; (2013), **‘**Temporal trends in the associations between age, sex and socioeconomic status after death from motor vehicle collisions in England and Wales: 1960–2009’.’Abstract’, Emergency Medicine Journal Vol 10, issue 1136. Pub: EMJ, published Online 6th Nov 2013.

Galton, F. (1889) ‘An instrument for measuring reaction time’. A Report of the British Association for the Advancement of Science, 59th meeting, page 784-

785. Retrieved 10th June 2013 from Biodiversity Heritage Library database. Retrieved electronically again on 25th July 2013 from http://www.biodiversitylibrary.org/item/93442#page/910/mode/1up

Gilbert, C; DVD (2007) 'Ultimate Driving Craft 1. : Driving 4 tomorrow.com. Retrieved again 11th October 2013.

Gilbert, C; DVD (2010) 'Ultimate Driving Craft 2 'Day'. : Driving 4 tomorrow.com. Retrieved again 11th October 2013.

Gilbert, C; DVD (2010) 'Ultimate Driving Craft 2 – 'Night'. : Driving 4 tomorrow.com. Retrieved again 11th October 2013.

Gilbert, C; DVD (2013) 'Ultimate Driving Craft 3 – 'Eyes on Main beam' Disk 1. Chapters 'Natural Focal Point', Effective Vision Scans'. : Driving 4 tomorrow.com. Retrieved again 31st December 2013.

Gilbert, C; DVD (2013) 'Ultimate Driving Craft 3 – 'Eyes on Main beam' Disk 2. Chapter 'London Run'. : Driving 4 tomorrow.com. Retrieved again 31st December 2013.

Gilbert, C; (2013) Driving 4 tomorrow.com 'Personal Tuition'. Retrieved again 31st December 2013.

Google Glass http://www.google.co.uk/glass/start/ 'What's New', 'How it Feels', 'What it Does', 'How to get One'. Retrieved 10th January 2014.

Google: BBC News: 'Google is to start building its own self-driving cars', http://www.bbc.co.uk/news/technology-27587558 retrieved 28th May 2014.

Gordon, T; (2013) cited in 'Careers' article 'Making Cars Smarter'. Journal of the Institution of Mechanical Engineers. Vol 26 No 12. 'Professional Engineering', page 68. December 2013.

G.P.S. Speedmaster Controls (2013) [Retrieved from:- http://www. GPS Speedometer Controls. Accessed again 1st August 2013]. This link includes a brief video of the device in action.

Halpert, Jullie; http://www.jeanknowscars.com/cool-tech/car-tech-news/drowsiness-detection-systems dated 8th October 2012. [Retrieved 3rd July 2014].

Harre, N; Sibley, C,G; (2007, p1160), 'Explicit and implicit self-enhancement biases in drivers and their relationship to driving violations and crash-risk optimism'. Accident Analysis and Prevention Vol 39, p 1155-1161. : Elsevier Ltd.

Harris, M; Tobin, D; (2013, August 18th) cited the work of others (anon), *Sunday Times* 'Driving', page 4-5 article "Help! I'm at the wheel but Hackers are driving".

Harris, Paul; Houston, John; (2008) paper 'Recklessness in Context: Individual and Situational Correlates to aggressive driving'. Environmental Design & Research Association. : Sage Online.

Heaven, D; (10th August 2013). Article 'Higher State of Mind'. New Scientist. No 2929. page 32-38, : Reed Business Information Ltd.

Hecht, J (2013, July 20th) article 'Just hang up and drive'. New Scientist. Vol 219 No 2926. page 24. : Reed Business Information Ltd.

Horswill, M.S; Weylen, A.E; Tobield, (2004). M.L;'Drivers ratings of different components of their own driving skill: A greater illusion of superiority for skills that relate to accident involvement. Journal of applied Social Psychology. Vol. 34 p 177-195. V.H. Winston and Son.

Horswill, M.S; Taylor, K; Newnam, S; Wetton, M; Hill, A; (2012). 'Even highly experienced drivers benefit from a brief hazard perception training intervention'. Journal 'Accident Analysis and Prevention' Vol 52 page 100-110. : Elsevier.

Hughes, P.K; Cole, B.L; (1986, page 337-391) 'What attracts attention when driving?'. Ergonomics. Volume 29, Issue 3 1986. : Taylor and Francis Online.

I.A.M. Manual 'Advanced Motoring' (1967, page 16). Queen Anne Press Ltd.

Isler, R.B; Starkey, N.J; Sheppard, P; Drew, M; (2008, June). The Frontal-lobe Project. Final Report. Retrieved on-line 15th January 2014. : University of Waikato, Traffic and Road Safety Research Group, New Zealand.

Kaehler, S. D. 'Fuzzy Logic Tutorial'. http://www.seattlerobotics.org/encoder/mar98/fuz/flindex.html. Published: in Encoder, the Newsletter of the Seattle Robotics Society. [Retrieved 3rd July 2014.]

Kim, R.R; Jochim, M; 'Towards dependable autonomous driving vehicles: A system level approach'. (2013). SIGBED Review. Vol 10. Issue 1. P 29-32. ACM.

Klauer, S.G; Guo, F; Simons-Morton, B.G; Ouirmet, (2014). M.C; Lee, S.E; Dingus, T.A; 'Distracted Driving and Risk of Road Crashes among Novice and Experienced Drivers'. New England Journal of Medicine, Vol: 370:1 page 54-59. 2nd January 2014. Pub: Massachusetts Medical Society.

Koubeissi, M.Z; Bartolomei, F; Beltagy, A; Picard, F; (2014). 'Electrical stimulation of a small brain area reversibly disrupts consciousness'. Journal Epilepsy & Behavour. Vol: 37. P32-35. Elsevier Inc.

Kowler, E; article 'Eye movements: The last 25 years'. Vision Research Vol 51, (2011) page 1457-1483. Elsevier Ltd.

Lajunem, T; Summala, H; (1995) Table 1 page 30. 'Driving experience, personality and skill and safety-Motive dimensions in driver's self-assessments'. Journal Person Individual Differences Vol.19, No 3, p 307-318. Elsevier Science ltd.

Lee, Yi-Ching (2010, September); Proceedings of the Human Factors and Ergonomics Society Annual Meeting. Vol. 54 no. 19 page 1531-1535.

Lehtonen, E; Lappi, O; Summala, H; article 'Anticipatory eye movements when approaching a curve on a rural road depend on working memory load'. Transportation Research Part F Vol 15 (2012), page 369-377. Elsevier Ltd.

Levinson, J; Askeland, J; Becker, J; Dobson J; Held, D; Kammel, S; Kolter, J.Z; Langer, D; Pink, O; Pratt, V; Solkolsky, M; Stank, G; StEvans, D; Teichman, A; Werling, M; Thrun, S; 'Towards fully autonomous driving: Systems and algorithems', (2011).Intelligent Vehicle Symposium (iv) IEEE Proceedings (5-9, June 2011). P163-168. IEEE.

Lim,Y; Tong, P;Zhang, W.J; Yu, Q; 'Artificial neural network modelling of driver handling behaviour in a driver-vehicle-environment system'. International Journal of Vehicle Design, Vol. 00, No 0фpp 000-000. Inderscience Enterprises Ltd.

Lunn, Bryan (1996, page 25-26); Chief Examiner, I.A.M. Article 'Driving With'. Milestones Summer Edition. Magazine of the Institute of Advanced Motorists.

Lucey, T; (1997) p 154-155. *Management Information Systems.* (8th ed). : Letts Educational. London.

Lyon, J., (2012, page 87-93); Advanced Driving. Chapter 6 'Observe to Anticipate'. : Hayns Publishing.

Mackenzie, Dana; (2005, 9th July); article 'Communication speed nears terminal velocity'. New Scientist. No 2507. page 35-38, citied Gallager (1963), Berrou and Glavieux (1993) and others. : Reed Business Information Ltd.

Malone, P., cited Huber, W., (2013, June 9th) and BMW (2013) in *Sunday Times* 'Driving', article 'Hands of the Wheel, Tommy-for you the driving is over', page 6-7.

Merton, R,K; (1968), 'The Matthew Effect in Science', Journal Science, Vol 159, p 56-63.Cited by Lyuten et al; Journal of Learning Disabilities, 2011, Vol.44(5), pp.444-458. Retrieved November 2014. Sage on line (2011).

Milanes, V; Alonso, J; Bouraoui, L; Ploeg, J; 'Cooperative measuring in close environments among cybercars and dual-mode cars', IEEE. Transactions on Intelligent Transportation Systems. Vol. 12 No 1, March 2011 p 15-24.

Milanes, V; Llorca, D.F; Villagra, J.P; Fernandez, C; Parra, I; Gonzalez, C; Sotelo, M.A; 'Intelligent automatic overtaking system using vision for vehicle detection'. Journal Expert Systems with Applications'. (2012). Vol.39 p 3362-3373. Elsevier Ltd.

Michon, J.A; (1978, p 12), 'Dealing with Danger', Summary Technical Report VK 79-01 by the Traffic Research Centre of the University of Groningen for a workshop in Gieten, The Netherlands, May 23-25 1978. Reproduced by the author with minor stylistic corrections. Accessed revision 2006. Author's note on its reissue in 2008, due to being out of print.

MIRA, Transport Research laboratory TRL. http://www.trl.co.uk/default.htm

Moderman, Hans; (2008, January 11th) 'Obituary', *The Times* (London).

Moore, G: (1965). 'Moore's Law' on silicon based microchip circuit miniaturisation. Cited from Mark Lundstrom, Purdue University. Network for Computational Nanotechnology. West Lafayette, USA. (retrieved electronically 16th December 2013).

Ozhan, T; Lajunen, T; Chliaoutakis, J. El; Parker,D Summala, H; (2006) ‘Cross cultural differences in driving skills: A comparison of six countries’. Journal Accident Analysis and Prevention Vol. 38 p 1011-1018). Elsevier Ltd.

Pettorossi, V.E; Ferraresi, A; Botti, F.M; Panichi, R; Barmack, N.H; article ‘Head position modulates optokinetic nystagmus’, Journal of Experimental Brain Research Vol 213 issue 1, (August 2011), page 141-152. Springer – Verlag.

Renge, K (1980) page 105 ‘An Analysis of Objects looked at: Using the ‘Verbal Report’ Method’. IATSS Research Vol 4. Page 95-106. International Association of Traffic and Safety Sciences.

Reuters via Airways News, report (2013, 10th December: Retrieved electronically, 18th December 2013 http://news.airwise.com/story/view/1386689104.html)

Ripley, B.D; (2008), ‘Pattern Recognition and Neural Networks’, page 146. 2nd Edition. Cambridge University Press. Cambridge.

Roadcraft (2007) The Police Driver’s handbook. © The Police Foundation, Printed & Published by The Stationery Office Limited.

Roadcraft (2013) The Police Driver’s handbook. © The Police Foundation, Printed & Published by The Stationery Office Limited.

Rufford, N; 2014, June29th) cited the work of Mercedes-Benze Engineers *Sunday Times* ‘Driving’, page 12 article “Nick Rufford’s First Drive”.

Shannon, C. E; (1948), Vol. 27, pp. 379–423, 623–656, July, October, ‘A. Mathematical Theory of Communication’. Reprinted with corrections from *The Bell System Technical Journal.*

.Schweizer, K., Ren, X., Xu, F., (2012, November). ‘The sources of the relationship between sustained attention and reasoning’ Journal ‘Intelligence’ Vol 41 page 51-58. Elsevier.

Sharp, G (1997) Human Aspects of Police Driving. Chapter 2 ‘Limitations to Brain Processing’, page 29. . Scottish Police College.

Sharp, G (1997) Human Aspects of Police Driving. Chapter 1, page 17-23. . Scottish Police College.

Sonkar, R.K; for Master of technology. Thesis ‘Navigation of automatic Vehicle using AI techniques’(2013). National Institute of Technology, Rourtela – 769008, Odisha, India.

Staff, R.T; Hogan, M.J; Whalley, L.J; (2014), ‘Aging Trajectories of fluid intelligence in later life: The influence of age, practice and childhood IQ on Raven’s Progressive Matrices’, Journal Intelligence, Vol 47, p194-201. Elsevier.

Stern, Eliahu (1999) ‘Reactions to congestion under time pressure’. Transportation Research Part C 7 p 75-90. Elsevier Science Ltd.

Sootheran, J; (2009) ‘How to be a better driver – Advanced Driving the essential guide’ Chapter 2, ‘Driving Hazards’ page 35, 2nd edition. Institute of Advanced Motorists.

Struth, Werner (2014) Bosch spokesperson. Sunday Times ‘Driving’ page 2 ‘news’ 2 Feb 2014.

(2013, June 9th) *Sunday Times* ‘Driving’ website. http://www.thesundaytimes.co.uk/sto/ingear/cars/article1269769.ece

Suβ, H-M; Oberauer, K; Wittmann, W.W; Wilhelm, O; Schulze, R; (2002). , ‘Working-memory capacity explains reasoning ability – and a little bit more’. Journal: Intelligence Vol 30, p 261-288. : Elsevier Science Inc.

Sullivan, J; ‘A fighter pilot’s survival guide to avoiding collisions’, ‘Advanced Driving. The magazine of the Institute of Advanced Motorists. Spring 2014, page 34-39. : Think, London.

Sumer, N; Ozkan, T; Lajunen, T; (2006). Asymetric relationship between driving and safety skills’. Journal of accident Analysis and Prevention Vol. 38 p 703-711. Elsevier Ltd.

Syed, Matthew. (2010), ‘Bounce How Champions are made’ Chapter 6 ‘The curse of choking and how to avoid it’. Page 177-178, : Forth Estate.

Tapia, E; Breitmeyer, B.G; (2011). ‘Visual Consciousness Revisited: Magnocellular and Paravocellular Contributions to Conscious and

Nonconscious Vision'. Journal of Psychological Science Vol. 22 No. 934 p 934-942. Sage.

Tewolde, S. Girma; (2012, page 1-7), 'Sensor and network Technology for Intelligent Transportation Systems', Electrical. & Computer. Eng. Dept., Kettering Univ., Flint, MI, USA. IEE Conference Proceedings 6-8 May 2012.

Topper, A.T; (1970), Very Advanced Driving,

The Driving Manual. The Driving Standards Agency. (First published 1992). Chapter 8, Defensive Driving. Page 170. . HMSO.

The Highway Code. page 27-28. (2007), Rule 126. Stopping Distances. : T.S.O. [The Stationery Office].

Tobin, Dominic; 2013, September 13th) cited the work of Luciana Iorio Italian Transport official., *Sunday Times* 'Driving' page 2 article "News".

Topper, A. Tom; (1970),p 16-18, 'Very Advanced Driving' Chapter 1 'Buppy Drivers'page16-18, Pub: Elliot Right Way Paperfonts, Kingswood, Surrey, U.K.

Turing, A.M, (October, 1950), Article 'Computing Machinery & Intelligence'. Journal: Mind. Vol. 236. Page 433-460. Oxford University Press.

Underwood, G; (2007) 'Visual attention and the transition from Novice to Advanced Driver'. Journal of Ergonomics Vol. 50 No 8 page 1235-1249. : Taylor & Frances.

Valldorf, J; Gessner, W; (Eds). (2006) 'Preface', Advanced Microsystems for Automotive Applications. Springer. ISBN: 978-3-540-33409-5.

Wei, J; Snider, J.M; Kim, J; Dolan, J.M; Rajkumer, R; Litkouhi, B; 'Towards a viable autonomous driving research platform'. (2013). IEEE. Intelligent Vehicle Symposium (iv) June 22dn-26th. Australia. P 763-770. IEEE.

Wen, D; Yan, G; Zheng, N-Y; Shen, L-C; Li, Li; (2011). 'Towards Cognitive vehicles'. Journal of Intelligent Transport Systems'. P 76-80. IEEE.

Westlake, D.C; (2015). Driving – An Information Management Cognitive Approach: By whom, man or machine? (In draft).

Westlake, D.C; (2015) 'Driving-An Information Management Cognitive Approach: who should drive man or machine?', cited Spollander, K; Abstract

[English] from original paper in Swedish, 'The effects of Commentary Driving: a study of Young Male Drivers', Report numbers: VTI-359, HS-041 275. Pub: Swedish National Road and Transport Research Institute.

Wilson, Clare; cited Bor, Daniel (2013, May 18th) in an article *New Scientist* page 38 'Why be Conscious?'. : Reed Business Information.

Wilson, Clare; cited Libet, Benjamin; (1980's) in an article *New Scientist*, (2013, May 18th) page 37 'The silent partner'. : Reed Business Information.

Winstone, C; Maheshai, V; Mannering, F; (2006) 'An exploration of the offset hypothesis using disaggregate data: The case of airbags and anti-lock-brakes. Journal of Risk and Uncertainty, Vol. 32(2), p 83-89. Springer.

Woodley, M.A., Nijenhuis, J.te., Murphy, R., (2013). 'Were the Victorians cleverer than us? The decline in general intelligence estimated from a meta-analysis of the slowing of simple reaction time. Journal 'Intelligence'. Vol 41. p 843-850. : Elsevier.

Woodley, M.A., Nijenhuis, J.te., Murphy, R., (June 2014). 'Is there a dysgenic secular trend towards slowing simple reaction time? Responding to a quartet of critical commentaries'. Journal 'Intelligence' Vol.46, p131-147. : Elsevier.

Wysocki.R.K; Young, J; (1990). p 32. *Information Systems: Management Principles in Action.* : John Wiley & Sons Inc. New York. Citing: Anthoney, R.N. (1965); Davis, G, (1974); Dickson, W.G, (1968).

Xianping, Fu; Guan, Xiao ; Peli, Eli ; Liu, Hongbo ; Luo, Gang;
IEEE Transactions on Intelligent Transportation Systems, March 2013, Vol.14(1), pp.303-312

Yeomans, K.A; (1968) Statistics for the Social Scientist Vol. 1 Chapter 3 'The description of data: averages and dispersion'. Section 3.9 'Skewness and Kurtosis'. Page 115, Fig 44. Penguin Education.

Zaiontz, C; Article:- 'One sample t-test', when the sample may not be normal but is reasonably symmetrically distributed around the measure of central tendency or mean. http://www.real-statistics.com/students-t-distribution/one-sample-t-test/ . Retrieved 30th June 2014.