

Sex differences in driving and insurance risk:
*understanding the neurobiological and
evolutionary foundations of the
differences*

Research by the Social Issues Research Centre (2004)
and Professor Geoffrey Beattie

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This report by Professor Geoffrey Beattie (University of Manchester) updates research by the Social Issues Research Centre, Oxford conducted in 2004.

It represents an overview of existing primary research into topics that have relevance to dangerous driving amongst young men, in particular it highlights the differences between male and female behaviour and draws conclusions from that research.

Executive Summary .3

Men and women exhibit different driving behaviours that affect their safety and insurance risk. Many factors underpin these differences, including neurobiological structures and hormonal processes shaped by evolution, and global socialisation practices. Each plays a part in explaining why men and women drivers have very different records in relation to accidents and insurance claims.

- Differences between male and female drivers in terms of crash rates are evident in a wide range of countries, including the United States, Europe, Asia and Africa, with males being significantly more at risk than females.
- Similar differences are evident regarding male and female pedestrians and accidents in the home and workplace.
- The differences are not easily explained in terms of levels of competence and driving skill of men and women. They derive from more fundamental differences in specific areas of behaviour and psychological functioning.
- There is extensive evidence to show that men, and young men in particular, tend to be more aggressive than women (in all known cultures) and they express aggression in a direct, rather than indirect, manner.

This has a very significant impact on driving – encouraging more competitive and hostile behaviour with consequent higher probabilities of having an accident.

- Indirect female forms of aggression depend critically upon empathetic skills; male forms of aggression do not. Women tend to be much more empathetic than men and this will have a direct impact on driving behaviour because women will be better able to take the other's perspective, for example, when the other person makes a violation or error the empathetic individual will respond less harshly as a consequence.
- Levels of deviant (rule-breaking) behaviour are significantly higher in men than in women. This manifests itself in a greater frequency of violation of traffic regulations, including speed limits, traffic controls, drink-driving, etc.
- Men also exhibit, on average, higher levels of sensation-seeking and risk-taking in a wide variety of settings.

The basis for this well-established sex difference has a hormonal and neurochemical basis – it is not simply a product of socialisation or experience.

- The differences between the sexes in terms of their risk-proneness while driving can be explained, at least in part, using an evolutionary psychology perspective. This proposes that much of neural circuitry of the human brain evolved to meet the requirements of societies and cultures very different from our own – that of the hunter gatherer – that existed for over 99% of our evolution as a species. Our 21st century skulls contain essentially 'stone-age' brains, and the brains of men and women are different in certain crucial respects.

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- Recent evidence also shows that the brain goes through a remodelling process during adolescence as the prefrontal cortex and the parietal cortex change in line with other physical developments during puberty. Cognitive abilities that rely on the functioning of these brain regions also change during adolescence. Executive functions such as selective attention and decision making are controlled by these brain areas and many studies have shown that processing speed, memory, inhibitory control and risk taking are not at an optimum during adolescence and that these processes continue to develop into adulthood. This may explain why young drivers are particularly prone to accidents.
- This remodelling also affects the ability of adolescents to interpret emotional expressions; they are significantly slower and less accurate compared with younger children and adults. Emotional recognition is a crucial component in being able to empathise with others – if you cannot recognize what others feel, you cannot hope to understand them. Research has also shown that higher levels of affective empathy are associated with lower levels of aggressive behaviour in adolescents and this may explain why adolescents drive more aggressively and are thus prone to more accidents than older drivers .
- Cars also represent defensible personal space and there are striking sex differences in how men and women use personal space and react to violations of it. Males habitually require more space than females in their everyday life and carry around with them a larger interpersonal bubble. They are also more sensitive to violations in interpersonal space than women and react more immediately and directly to such violations. This might well explain why they are so sensitive to any space violations by others when driving, like tail gating or being recklessly overtaken and why they respond so immediately and so aggressively. The differential use of space by men and women is probably also biologically hardwired in the brain because although there are striking cultural differences in the use of space, the differences between the sexes seem to be maintained across a wide variety of cultures.
- Stone-age man did not drive. But the legacy of his hunting, aggressive and risk-taking past – qualities that enabled him to survive and mate, thereby passing on his genes to future generations – are still evident in the way in which he typically drives his car.
- A report published by the Department of Gender and Women's Health at the World Health Organisation has called for recognition of these fundamental differences between men and women drivers and the development of gender-differentiated policies in relevant areas.
- In the light of these new understandings of the neurobiological underpinnings of driving behaviour, we need more theoretically focussed approaches to tackle risky or aggressive driving. Existing interventions focus on a range of attitudinal and cognitive aspects of driving, but if they are to be really successful they will need to recognize the neurobiological substrates, including the role of road rage, as a specific emotional and motivational response, empathy as a basic sex-biased characteristic, and interventions must also display awareness of how the adolescent brain is being remodelled to tailor interventions more effectively.

Significant differences between men and women in terms of their driving behaviour and accident rates have consistently been found over a considerable period of time in the UK, mainland Europe, the United States, Australia and in many other countries. New research in neuroscience and neuropsychology into how male and female brains develop and function may provide novel insights into why these differences in driving behaviour and accident rates do emerge. Specifically there may be differences between the structural organisations of male and female brains which can provide some insight here. This new research into the neurobiological underpinnings of complex activities like driving also reveal that adolescence is a particularly turbulent time in terms of new structural organization and remodelling and this particular research focus may help us understand why young drivers are particularly prone to accidents.

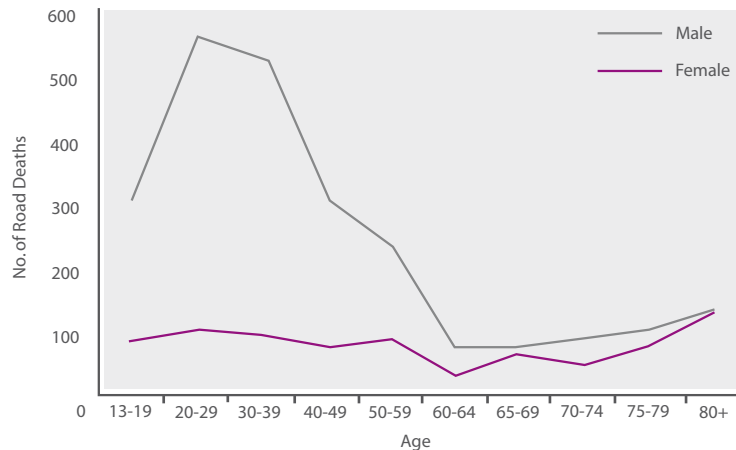
In all studies and analyses, without exception, men have been shown to have a higher rate of accidents than women. This gender difference is most marked in the population under the age of 25 years, but is also evident among older drivers. The difference between the sexes in terms of the number of fatalities resulting from road crashes is similarly marked. (See, for example, Evans (1991), McKenna et al (1998), Parker et al (1995), Abel-Aty and As-Saidi (2000), Waller et al (2001), Waylen and McKenna (2002), Elliott, Shope, Raghunathan and Waller (2006)). In a publication for the First United Nations Global Road Safety Week (23-29th April 2007), the WHO stated that road traffic injuries are the second leading cause of death for people aged 5–25 years. Among this age group, young men are nearly three times more likely to be killed or injured on the roads than young women. Globally, more than 40% of all road traffic deaths occur among the 0–25 age group. Males account for 75% of all road traffic fatalities among those under 25 years of age and in particular are likely to drive at excessive or inappropriate speeds. Young male teenage drivers are at least five times more likely to be involved in a crash than drivers aged 30 years and older, at all alcohol levels above zero and young male drivers have been found to use seat-belts less frequently than other groups.

The scale of this difference between the sexes is very substantial. Chipman et al (1992), for example, show that men have double the number of crashes (per 1,000 drivers) than women. Waller et al (2001) also note that in addition to having a higher number of crashes, men incur their first crash earlier in their driving career and are more likely than women to be held to blame for the incident. Norris et al (2000) and others attribute this greater level of crash-proneness to higher driving speeds among men and less regard for traffic laws.

Waylen and McKenna (2002) note that the pattern of road accident involvement also differs between the sexes. Men are more likely than women to be involved in crashes that occur on bends, in the dark or those that involve overtaking. Women, on the other hand, have a greater frequency of crashes occurring at junctions than men. This supports the suggestion by Storie (1977) that men are more at risk from accidents involving high speed while women are more likely to be involved in accidents resulting from perceptual judgement errors.

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The figures from the UK Department for Transport for all road deaths in 2001 are summarised in Figure 1. below.



From Figure 1. we can see that in the age category 20-29 years the fatality rate for males (including drivers, passengers, pedestrians, cyclists, etc.) was 535% greater than that of females. The difference between the sexes declined sharply with age – the difference between men and women in their sixties and older being insignificant. This is consistent with the findings of Maycock et al (1991) that the greatest difference between males and females in this context is in the 16-20 and 21-24 age groups.

Looking at Table 1. which shows traffic offences published by the Home Office (2006) we can see that the percentage of these offence committed by men is extremely high compared to women, for example it was male drivers who were responsible for causing death or bodily harm in 94% of the cases.

Table 1. Findings of guilt at all courts by type offence and sex of offender.

Offence Type	Percentage Male					
	2000	2001	2002	2003	2004	2005
Causing death or bodily harm	95	94	94	94	94	94
Dangerous Driving	97	97	97	96	97	97
Driving etc. after consuming alcohol or taking drugs	90	90	89	89	89	88
Accident offences	88	88	88	87	87	87
Unauthorised taking or theft of a motor vehicle	96	96	96	95	96	95
Speed limit offences	85	84	83	82	82	82

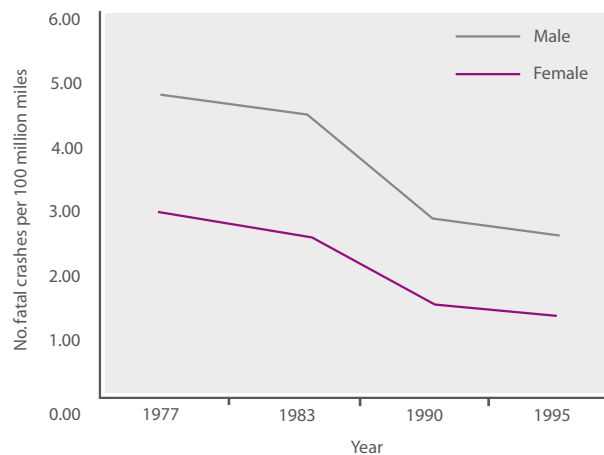
This increased level of risk among young men is not confined to driving. The WHO (1999) and (2002) report that men are also more likely to die from falls, drowning, poisoning and a range of other events. Only in the case of deaths in fires are women slightly more over-represented than men. The report also notes that injury

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and fatality rates are higher among men for every type of road injury victim in several developing countries. In Kampala, Uganda, for example, males outnumbered females by between 2 and 7 to 1 among injured vehicle drivers, passengers and pedestrians. In the United States male drivers are much more likely than females to be injured or killed in road accidents – they account for 71% of all driver fatalities. This figure has remained virtually constant since 1975.

To some extent, of course, these differences may be partially explained by the greater exposure of males to potential accidents due to the relatively higher number of licensed drivers and greater annual mileages. If such factors were at work, however, we would expect a sharp difference between the level of male driver injuries and fatalities and those resulting from being a pedestrian, passenger, cyclist etc. Such a difference is not evident, and the risk-proneness of men while driving is directly reflective of their risk in a wide range of other contexts. This is demonstrated in Figure 2 below, derived from the US Insurance Institute for Highway Safety report, 2001.

The data illustrated in Figure 2 relate to driver deaths per 100 million miles driven, thus controlling for differential exposure to risk. While the number of driver deaths fell substantially between 1977 and 1995, the relative male/female ratios remained substantially the same throughout the period. (See also Mayhew et al (2003)).



The WHO (2002) report noted above highlights factors that might be of relevance to explaining this marked gender difference, including greater propensity towards risk-taking, alcohol use, anti-social behaviour etc.

“‘Masculinity’ may be hazardous to health. Gender role socialisation and the association of masculinity with risk-taking behaviour, acceptance of risk and a disregard of pain and injury may be factors leading to the hazardous actions on the part of men. These include, for example, excessive consumption of alcohol, drug use, aggressive behaviour, to be in control of situations, and risky driving.”

Further research is proposed to identify such factors more precisely and, in particular, the report concludes:

“Research is needed to examine the potential benefits of gender and age-differentiated policies for issuance of driving licences and related issues.1”

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The fact that this WHO report was prepared by the Department for Gender and Women's Health suggests that driving-related policies that differentiate between genders are not seen as cutting across broad notions of equality in this context.

The WHO report and other research documents put forward various reasons to explain the observed sex differences in the risk of injury or death while driving. These, overall, fall into three distinct groups, indicating differential levels of:

- aggression
- speeding and violation of traffic laws
- sensation-seeking and risk-taking

These and related factors are considered below.

Sex differences in aggression and driving behaviour .9

There is a vast literature concerning studies of sex differences in aggression focusing on biological, physiological, evolutionary, developmental, social and cultural factors. There is an overwhelming consensus that human males are more aggressive, and display aggression in different ways, compared with their female counterparts. Baron-Cohen (2003) explains that men display direct aggression in such overt acts as hitting or pushing whereas women tend to be more covert in their aggression and display it in acts such as gossiping or through catty remarks, which forms a major part of bitching. However, both gossiping and bitching are not just about covert attacks on selected individuals; they are also about bonding with the person that you are sharing the gossip or bitchy comments with. This, of course, in evolutionary terms is always a risky strategy because you have to make critical decisions about the nature, mood and general psychological state of the person that you are sharing the gossip or bitchy comments with. If they are not receptive and do not reciprocate then this can leave the originator of the comments isolated and vulnerable. Of course, deciding who to share such comments with does depend on strong empathetic ability, and general social intelligence, which women do possess to a greater degree than men (Baron-Cohen, (2003)). Higher social intelligence also allows women to select exactly the right negative comments, which may have the most hurtful effects on the individuals on the receiving end. Males, on the other hand, use not just a more direct strategy of aggression, but one that does not depend to the same extent on empathetic ability or social intelligence. In other words, the aggression is not necessarily predicated on sometimes difficult social judgments about the emotional state, the cognitive state or the motivational state of the potential target. In evolutionary terms, this direct form of aggression is a very efficient strategy for establishing social dominance or resolving social conflict. The bravest and most skilled fighters in male-male competition generally earn the highest social status.

The greatest differences are seen from puberty to early adulthood although differences are evident from the age of two years. Parallel sex differences are found in virtually all other species of animal, from the sabre-toothed tiger to the five-spined stickleback. The hamster may be one of very few exceptions.

It is beyond the scope of this review paper to consider even a small fraction of this material. An excellent, but now slightly dated, review can be found in Björkqvist, K. (1994). See also Marsh and Campbell (1986). A definitive study by Rita Simon and her colleagues (1991) examined violent crime rates in 31 countries across a time period of 18 years. They found no time period or country where female aggression exceeded that of males.

Baker (1992) found that homicide rates are between 5 and 10 times higher for males than for females. The differences between the sexes were the greatest between the ages of 15-19 and 20-34 (see also Runyan and Gerken (1991)).

Some social scientists have challenged the allegedly simplistic account of aggression and sex differences based on measures of physical violence. They argue that aggression may also underlie behaviours that do not involve physical expressions – e.g. manipulation, exclusion, gossip, etc. (See, for example, Crick and

Sex differences in aggression and driving behaviour .10

Grottpeter (1995)). They suggest that levels of aggression as a whole may not be significantly different between the sexes, rather it is the manner in which it is expressed that is gender-specific. While there may be a valid point here (see Paquette and Underwood (1999)), it relies on a broadening of the definition of aggression to include a wide range of additional social behaviours that are not ordinarily defined as aggressive. For the purposes of this review, therefore, the more conventional definition of aggressive behaviour will be retained.

The literature which focuses on the differences in aggressive driving is substantially smaller than the literature on sex differences in aggressive behaviour, which is very extensive. It is also the case that some less than convincing proxies for aggressive behaviour have been used in some studies. Doob and Gross (1989), for example, used horn-honking as an indirect measure for aggression. They found that males honked their horns three times more quickly than females when, for example, drivers in front did not move on a green traffic light.

More convincing evidence of sex differences in driving behaviour comes from Mizell (1997) who studied police and news reports of aggressive driving incidents and found that males were much more frequently involved in such behaviours than females.

An earlier study in the UK by Parry (1998) examined the attitudes and behaviours of 279 British motorists. The analysis of scaled items designed to measure 'aggressiveness' indicated that the highest scores for aggression on the road were associated with male drivers aged 17 to 35. Their average aggression scores were twice those recorded for middle-aged males. Females aged 17 to 35 had average aggression scores comparable to those of middle-aged male drivers.

A study by Lajunen and Parker (2001) used self reports of subjects' levels of aggressive driving and found significant gender and age effects. Among men, aggressive driving was most associated with the lower age groups. Among women, however, who reported fewer behaviours of this type, age was a much less significant factor, in line with the results obtained by Parry above.

Stradling and Meadows (1999) report that while aggressive driving in males does, indeed, decline with age, the levels are greater than those for females in all age categories.

Recent evidence shows that the brain goes through a remodelling process during adolescence as the prefrontal cortex and the parietal cortex (Choudhury, Blakemore and Charman, (2006)) change in line with other physical developments during puberty. Cognitive abilities that rely on the functioning of these brain regions during adolescence also change. Executive functions such as selective attention, decision making are controlled by these brain areas and many studies have shown that processing speed (Luna, Garver, Urban, Lazar and Sweeney, (2004)), memory (MacKinlay, Charman and Karmiloff-Smith, (2003)) inhibitory control (Leon-Carrion, Garcia-Orza and Perez-Santamanria, (2004)) and risk taking (Gardner and Steinberg (2005)) are not at an optimum during adolescence and continue to develop into adulthood.

Sex differences in aggression and driving behaviour .11

An important implication of these changes is in the interpretation of emotions. Decoding facial expressions in an appropriate manner aids an individual's ability to understand and adapt to the social environment and thus is a crucial part of social interaction (Thomas, Bellis, Graham and LaBar, (2007)). However, it has been demonstrated that adolescent brains are not fully developed to interpret emotions. McGivern, Anderson, Byrd, Mutter and Reilly (2002) found that at the time of puberty onset there is a decline in the ability of adolescents to match faces to the emotions they represent compared to the ability of younger children. Thomas, et al (2007) showed that adults show more sensitivity to subtle changes in emotional expression than adolescents.

Emotional recognition is important in being able to empathise with others. Empathy involves identifying the emotions and thoughts of others and responding to them with an appropriate response, be it emotional or behavioural. Baron-Cohen (2003) believes that the female brain spontaneously empathises to a greater extent than the male brain because of how it is structurally organized in terms of basic neurophysiology. As a result adolescent males may display greater levels of aggression than their female equivalents as empathy has been found to actively inhibit aggression (Miller and Eisenberg, 1988; Richardson, Hammock, Smith, Gardner and Manuel, (1994)). It has been suggested that empathic reactions play an important function in the reduction or inhibition of aggressive and other types of antisocial behaviour toward other people (Parke and Slaby, (1983)). Individuals who are able to experience and appreciate the negative reactions of others that result from their aggressive behaviour, or those who can imagine what they themselves would feel if they were to be on the receiving end of the aggression of others, will be less inclined to display aggression in their everyday life. de Kemp, Overbeek, de Wied, Engels and Scholte, (2007) showed that higher levels of affective empathy were associated with lower levels of delinquent behaviour and also lower levels of aggressive behaviour in adolescents and Miller and Eisenberg (1988) found that empathy is negatively related to aggression, externalizing and antisocial behaviours, and enactment and receipt of physical abuse.

The implications of this recent research on the structural organization of male and female brains (Choudhury, Blakemore and Charman, (2006)) and the differing psychological skills associated with this for driving behaviour should be clear. Male aggression would seem to be biologically hard-wired in evolutionary terms. It is less discriminating than more covert female forms of aggression and does not depend upon complex social judgments requiring higher levels of social intelligence. It can be triggered by mild frustrations, like the blocking of goal states (Dollard, Doob, Miller, Mower and Sears (1939); Fortman, (2005)). This may explain why male drivers can act so aggressively at times, and are so indiscriminate in their aggression. They may be frustrated by the slowness of the traffic or the fact that some driver has cut right in front of them but what they are not doing is trying to empathise with the other driver or trying to understand what the other driver might be feeling at that particular point in time which led to their action. The fact that such aggressive acts is important for establishing the position of the individual in a social hierarchy would also lead one to predict that such aggressive forms of driving would be more prevalent when young male drivers (who will be especially sensitive to the process of establishing their place in a

Sex differences in aggression and driving behaviour .12

social hierarchy) are accompanied by other young passengers who can also experience the act and understand its practical and symbolic significance. This prediction is borne out by empirical observation which has found that driving violations amongst young male drivers are significantly more likely when the driver is accompanied by others than when they are on their own (Chen, Baker, Braver and Li, (2000)). The fact that all human brains start a process of remodelling at puberty which continues through adolescence and is not complete until early adulthood, also partly explains why these processes are particularly acute with young drivers. They are unable to interpret human emotional expression as quickly or as accurately as they could before puberty, or as they will when they reach young adulthood. Given that our empathetic ability depends upon our skills at interpreting another human being's underlying emotion one can see that empathy will be disrupted during this time, which will have a significantly greater effect for young males already with potential difficulties in this area. Understanding the neurobiological underpinnings of the male brain and how it connects to social processes in the male group can thus provide us with considerable insight into some of the more basic aspects of male driver behaviour.

There are, it must be acknowledged, a small number of studies that have failed to find sex differences in aspects of aggressive driving behaviour. Hauber (1980), for example, found no significant differences between men and women in terms of their horn honking and other behaviours (but note that the caveats raised above in relation to horn honking as a measure of aggression also apply here). Novaco (1989) also concludes that 'self-endangering' and provocative behaviours are characteristic of both male and female drivers. The overwhelming evidence, however, from both experimental and observational studies indicates that differences between the sexes in levels of aggressive driver behaviour are consistent with the differences in accident rates. The only real area of contention is in relation to the explanation of these differences – i.e. the extent to which they are the product of genetic, social, developmental or experiential factors. A brief discussion of these issues is contained in the final section below.

Male space and driving behaviour .13

Marsh and Collett (1986) invoke the notion of the 'territorial imperative'¹ and associated aggressive defence behaviour to explain the high levels of aggression displayed by males when driving. 'The Territorial Imperative' written by Robert Ardrey (1966) promotes the idea that humans exhibit the same instinct to protect territory as much as animals do. Marsh and Collett (1986) compare the car to both 'home turf' and to an extension of body space. When these private zones are 'invaded' by, for example, tailgating or other manoeuvres, defensive aggression is triggered that matches the patterns of male territorial defence seen in humans across all cultures and in other species of animal. The authors note (page 162 ff):

"While territorial defence is largely a male prerogative, it is young men in particular who make the most use of the car as a weapon. In many cases this is because the automobile is their only personally owned territory. In Europe and America, getting one's own car is an important step on the road to independence. The family home is a territory dominated by parents. The car, on the other hand, is one that the fledgling adult can control himself. Because it is so closely related to self definition, the prospect of its being defended is greatly increased. Later on in life, when other territories such as a home or one's own office are acquired, the significance of the car in this respect becomes slightly diminished ... The territorial component of the car helps us to understand the cause of the very high rate of car crashes involving young men."

Authors such as Aiello and Aiello (1974) found that as children grow older they require more personal space and that males in particular maintain greater distances between themselves and interactional partners than do females. Males in every culture compete against each other for success in social rank (Baron-Cohen, (2003)) and therefore males may find it harder to share space on the roads with other men. A study by Burford, Foley, Rollins and Rosario (1996) found that boys are less likely to share than girls and that in order to resolve problems of sharing girls were more inclined to negotiate whereas boys were more likely to be aggressive. This reflects the evolutionary gender difference that males are interested in personal gain and females in maintaining group harmony. Many studies have found that women are more co-operative and generous than men, see for example, Aranoff and Tedeschi, (1968) and Ortmann and Tichy, (1996) and this may come into play on the roads.

Males habitually require more space than females (Alder and Iverson, (1974); but see also Li and Li, (2007)) in their everyday life, this applies to comparisons of males and females sitting, standing, walking, talking and so on. They carry around with them a larger interpersonal bubble. They are also more sensitive to violations in interpersonal space than women and react more immediately and directly in terms of compensation with a number of forms of nonverbal behaviour (Argyle and Dean, (1965)). The corollary of this is that they understand the real psychological significance of space violation and would seem more than prepared to respond appropriately. This might well explain why they are so sensitive to any space violations by others when driving, like tail gating or being recklessly overtaken and why they respond so immediately and so aggressively. They require higher degrees of personal space and react badly when this personal space is violated or infringed in any way. The differential use of space by men and women is probably also biologically hardwired in the brain because although there are striking cultural differences in the use of space with Arab nations using much closer interpersonal distance than western nation (Hall and Whyte, (1960), Watson and Graves (1966)), the differences between the sexes seem to be maintained across a wide variety of cultures.

¹ A reference to the book of the same name written by Robert Ardrey in 1966 which promoted the idea that humans just like animals exhibit an instinct to protect territory.

Sex differences in traffic regulation violations .14

In the UK, Home Office statistics show that in 2004 90% of serious motoring offences were committed by men. Serious offences include dangerous driving, loading offences, theft of a motor vehicle, or causing death or bodily harm. The most common offences committed by women include obstruction, waiting and parking offences, speeding and road tax evasion. Storie (1977), found that men were more likely than women to be involved in accidents resulting from excessive speed. Michiels and Schneider (1984) attributed the higher driving speeds of men, and young men in particular, to their higher involvement in deviant and anti-social behaviours in general. Exceeding speed limits was just one manifestation of this broader pattern. This is supported by Elander et al (1993).

In Germany, the Statistisches Bundesamt (the Federal Statistics Office) analysed accident data in 1986 and reported that females were significantly less involved than males in accidents caused by speeding and by veering off road lanes. Norris et al (2000) confirmed these findings in the United States and suggested that pre-existing 'characterological', situational, and behavioural risk factors could explain the observed sex and age differences in accident rates. The authors of this report also noted that a proportion of the higher accident rates for male drivers could be explained by their greater tendency to disregard speed limits and other traffic rules.

Stradling and Meadows (1999), Stradling (2000) and Ozkan and Lajunen (2005) similarly note that male drivers are not only more likely to drive faster, they are also more likely to commit a range of Highway Code violations.

A number of other studies confirm these consistent findings – e.g. Trankle et al (1992), French et al (1992), Parker et al (1992), Furnham and Saipé (1993), etc. The exception to this pattern is a study by Wasielewski (1984), whose observational study failed to detect any significant difference in speed between male and female drivers however the evidence gathered by the Home Office in their traffic offences study (see Table 1) provides robust evidence to the contrary.

For other types of traffic violation, Waller et al (2000) report that men are twice as likely than women to breach regulations and receive citations from the police. They also tend to commit their first offence at a younger age. Lawton et al (1997) found the same effect and suggested that differences between the genders in terms of accident rates could almost entirely be explained by the differential tendency to commit driving violations. Once the relationship between gender and driving violations was removed, gender was no longer predictive of accidents.

A study by Yagil (1998) in Israel, conducted among university students, indicated that females had a stronger sense of obligation to obey traffic laws. They were also more likely to evaluate traffic laws positively. The observed gender differences were particularly pronounced among young drivers. Women were more likely than men to view the content of traffic laws as important, clear and reasonable. This resulted in a stronger sense of obligation to obey traffic laws. Women reported that they would comply with traffic laws even in situations where non-compliance was not perceived as risky. Men, on the other hand, tended to

Sex differences in traffic regulation violations .15

overestimate their driving ability and feel more confident in complying selectively with traffic laws. Young males in particular were more likely to evaluate traffic laws negatively and to underestimate the risks associated with traffic violations.

Parker and Stradling (1998) found that in the UK 40% of male drivers could be classed as 'high violators', compared with 20% of female drivers. Violations included such behaviours as crossing lights on red, driving close to the vehicle in front, driving over the legal limit for blood alcohol, being involved in unofficial races with other drivers, etc. as well as exceeding speed limits. For speeding, the authors found, on the basis of national surveys of drivers, that twice the number of males had been stopped by the police for speeding compared with females. When presented with the statement 'I disregard the speed limits late at night or very early in the morning', 22% of male drivers agreed with the statement, compared with only 8% of females. Males also reported higher feelings of excitement when driving fast.

Extensive support for such findings exists in other studies, including Reason et al (1990), Meadows (1994), Furnham and Saipe (1993), etc.

In addition to speeding and other driving violations, males, and young males in particular, are the most likely group to drive after drinking – see, for example, Storie (1977), Caetano and Clark (2000), Anderson and Ingram (2001). This group is also the most likely to drive under the influence of drugs – see, for example, Lancaster and Ward (2001). Home Office statistics show that of those convicted of drink driving offences in 2002, 97% were male.

Shinar et al (2001) found that in the United States, based on self-report data, women were significantly more likely than men to abstain from drinking before driving. Similar results were obtained in an earlier study by the National Highway Traffic Safety Administration, NHTSA (1995).

While not necessarily linked directly to accident rates, but possibly to injuries sustained in accidents, a number of studies have shown that seat-belt wearing tends to be less frequent among male drivers than among females – see, for example, Jonah (1990), Waxweiler et al (1993), Shinar et al (2001). Begg and Langley (2000) also note that failure to wear a seat belt is often associated with other 'deviant' behaviours such as drug use, drinking, etc.

Sensation seeking and risk-taking .16

There is a very substantial research literature that clearly demonstrates broad sex differences in risk-taking and sensation-seeking behaviours. Virtually all studies show that men engage in these activities far more frequently than women and that these tendencies are spread across a wide range of behaviours, including driving. Sensation-seeking, as a measurable personality trait defined by Zuckerman (1979, 1994, 1996), Zuckerman et al (1978), has frequently been shown to correlate with various types of anti-social conduct. Such findings are confirmed by, for example, McCourt et al (1993), Wagner (2001), Pyszczynski (2002), etc.

The phenomenon has been studied from a variety of perspectives, including social, psychological and economic approaches – see Oetting *et al* (1998), Deery and Fildes (1999), Fromme *et al* (1999), etc. Many of these include a specific focus on driving behaviour. Increasingly, however, the focus is turning towards biosocial explanations of both the phenomenon of sensation-seeking and the observed sex differences – e.g. McCourt *et al* (1993).

Risk taking and sensation seeking are higher in young males than in young females and this has a strong biological basis with low levels of MAO (monoamine oxidase) correlating with high sensation seeking. MAO levels increase with time and are lower in males than females, (Nell, (2000)). Daitzman *et al* (1978) conducted an early investigation into the relationship between sensation-seeking and risk-taking and levels of male testosterone. This has been followed by further investigations conducted by, among others, Daitzman and Zuckerman (1980), Dabbs and Morris (1990), Bogaert and Fisher (1995), Gerra *et al* (1999), etc. All of these have found a positive correlation between sensation-seeking and testosterone levels, providing a very simple explanation of why men are more prone to engage in such behaviours, independent of child-rearing, socialisation, education and other factors. A study by Wang *et al* (1997) is one of the few exceptions in an otherwise consistent corpus of knowledge.

Males exceed females on physically risky forms of sensation seeking (Zuckerman, (1994)) which in turn correlate significantly with their tendency to engage in physically dangerous activities such as hazardous sports like rock climbing or white water rafting, volunteering for drug experiments, hazardous army combat and even criminal behaviour with all its inherent risks (Zuckerman, (1994)). The very significant sex differences in rate of death from traffic accidents seem to be attributable to men's more frequent speeding, tailgating, and running red lights (Wilson and Daly, (1985)). Such accidents are directly attributable to the greater willingness by boys to take risks involving potential physical injury (Ginsburg and Miller, (1982)). Cronin (1991) believes that in nature handicaps that seem unexplainable in terms of Darwinism such as the elaborateness of a peacock's tail and the stripes on a zebra may attract a female by signalling a mating advantage to her. These handicaps give the message that the male can support these high costs and still survive. Nell (2002) believes that young men who indulge in high risk activities are similar to the peacock and are saying "Look at me! I have so much strength and skill that I am fearless, I will survive no matter how much I drink or how fast I drive"

Sensation seeking and risk-taking .17

Other studies have examined the additional roles of neurotransmitters such as dopamine and serotonin in the mediation of sensation-seeking and risk-taking behaviours, finding positive correlations in most cases—e.g. Gerra *et al* (2000), Netter *et al* (1996), etc. The stress hormone, cortisol, has also been shown to be associated with levels of sensation-seeking – see Rosenblitt *et al* (2001).

The relationship between hormone levels and both sensation-seeking and risk-taking is, of course, rather more complex than the image of ‘testosterone-fuelled young male drivers’ might suggest. Zuckerman (1991), for example, has found that levels of testosterone can be influenced by situational factors such as aggression and conflict. Nonetheless, it is the case, as Ridley (1999) has noted that while females have, on average, 40 nanograms of testosterone in each decilitre of their blood, males have 300 to 1000 nanograms of testosterone per decilitre of blood. This, he argues, is the basis of the observed sex differences. Other studies have also shown that although the levels of testosterone are very much lower on average in women, certain types of female behaviour are related to variations in the level of the hormone. In a study by Dabbs *et al* (1988) female prisoners who had committed violent crimes which were unprovoked were found to have higher levels of testosterone than females who had committed violent crimes due to provocation or had committed non-violent crimes.

The conclusion, then, must be that although there is no definitive chemistry of bad driving at least some of the variation between the sexes in the context of risk-taking and sensation-seeking is accounted for by variations in levels of testosterone (in interaction with other hormones and neurochemical changes) and by the very large differences in average testosterone levels between the sexes.

Educating adolescent and aggressive drivers .18

Negative adolescent driving behaviour is an issue of major contemporary interest. Effective ways to tackle this issue are now critical particularly as the number of reported accidents and deaths due to aggressive or risky behaviour are still on the increase (Asbridge, Smart and Mann, (2006)) and many studies looking at the demographic characteristics of aggressive drivers and road rage perpetrators show that these drivers are more likely to be young and male eg. Joint (1995).

The underlying determinants of aggressive driving behaviour may range from inexperience, pleasure seeking, risk taking or an aggressive personality (Asbridge, Smart and Mann, (2006)). Proposal of how to tackle these behaviours are diverse; some have suggested introducing stricter laws on road rage behaviours such as shouting, shaking fists and commenting negatively on other peoples driving. Studies such as Joint (1995) have found that the following behaviours are the most important catalysts leading to road rage: Aggressive tailgating (62% of cases), headlight flashing (60% of cases), obscene gesturing (48% of cases), deliberately obstructing other vehicles (21% of cases) and verbal abuse (16% of cases). Other interventions such as screening new drivers according to Diagnostic and Statistical Manual of Mental Disorders could identify potential road rage cases have been proposed. These drivers could then be filtered into further driver training programs that facilitate non aggressive driving practises and anger management (Asbridge et al, 2006). It has been suggested that car redesign may prevent some aggressive behaviours, for example, cars could be redesigned to prevent excessive headlight flashing and horn blowing by having circuits installed that only allow a few flashes of the headlights or a few horn blasts (Asbridge et al, 2006). Cars such as the Mercedes-Benz and Jaguar have already been designed to prevent tailgating with distance control systems and a microcomputer to constantly maintain a safe distance behind the vehicle in front (Crawford, (1999)). Prevention messages in the media aimed at increasing knowledge and educating people to dangers have met with mixed success (Morrison, Petticrew and Thomson, (2003)). Increased autonomy during adolescence may prevent young drivers from accepting prevention messages particularly if the message contradicts their independent decision-making (Ary, Tildesley, Hops and Andrews, (1993)).

Prevention efforts targeted at new drivers to reduce crashes include regulatory approaches such as driver education, however, many studies have found that these interventions are not effective (Mayhew and Simpson, (2002)) and worse still others have found that these interventions produce a "safety disbenefit" with crash rates increasing after participation in such programs rather than decreasing (Potvin, Champagne and Laberge-Nadeau, (1998)). This may be because this type of training fails to teach the knowledge and skills that are critical for safe driving (Tilleczek, (2004)), students may not be motivated to use the safety skills they are taught. Driver education may foster overconfidence and fail to adequately address lifestyle issues such as risk taking behaviour (Mayhew and Simpson, (2002)). Tilleczek (2004) suggests that safety messages surrounding driving should be given in the classroom and peers should be able to talk aloud about issues, she also states that messages also need to be tailored to the small number of youth that are about to take undue risks in cars.

Educating adolescent and aggressive drivers .19

Despite the reported shortcomings of some driver behaviour interventions some successes have been demonstrated with brief approaches, such as single session interventions with professionals who offer advice on issues relating to risk taking behaviours. This type of intervention has successfully decreased adolescent drink driving and other risk taking behaviours. Monti, Colby, Barnett, Spirito, Rohsenow, Myers, Wollard and Lewander, (1999) conducted a study with adolescents being treated in an emergency room after an alcohol related event. Adolescents either received a motivational intervention or just standard hospital care. Youths who received the motivational intervention were less likely to drive after drinking at a 6-month follow up compared to the adolescents who had received only hospital care.

A promising countermeasure for reducing the accident risk in adolescent drivers is graduated licensing in (use for example in, America, Canada and New Zealand). With this system driving privileges are given in phases and to begin with driving experiences are limited to lower risk situations. Drivers have to complete three stages the first only allows drivers to ride with an experience instructor; the second stage prohibits unsupervised high risk driving such as driving at night. Other limitations are also in place such as restrictions on carrying teenage passengers and full licenses are delayed if any convictions occur for any traffic violations and a zero tolerance policy is taken on drink driving (McCarrt, Leaf, Farmer, Ferguson and Williams, (2001)).

Florida was one of the first states to implement this graduated licensing system and the initial effects reported a 9% reduction in the fatal and injury crash involvement rates for 15, 16 and 17 year olds in the first year (Ulmer, Preusser, Williams, Ferguson and Farmer, (2000)). Under the same system crash and injury reductions were reported in New Zealand (Langley, Wagenaar and Begg, (1996)) and in Canada (Boase and Tasca, 1998). McCarrt et al, (2001)) found that the graduated licensing system was effective in changing teenagers self reported behaviours related to licensing and learning to drive. They found that teenagers under this system were more likely to hold permits for a longer amount of time, obtain more practice of driving during the permit stage and there was a marked reduction in the number of teenagers with no driving practice. Reported driving after drinking declined from 24% to 20% and riding with drunken friends declined from 41% to 37%.

Interventions to specifically target aggressive drivers are also in place. Counselling has been demonstrated to help people cope with maladaptive anger in general (Sharkin, (1988)) and therefore is likely to be affective in helping individuals with driving anger. Sharkin, (2004) stresses that counselling should take into account the unique aspects of the driving situation, for instance, the inability to communicate directly with other drivers and the risk of serious injury if safe driving is compromised. Time management strategies may be useful in reducing driver anger in those individuals who do not keep time well by reducing the feelings of pressure and being rushed (Sharkin, (2004)). Cognitive behavioural interventions have been found to successfully reduce driver anger, aggressive forms of anger expression while driving, and trait anger scores (Deffenbacher, Filetti, Lynch. Dahlen and Oetting, (2002)).

Educating adolescent and aggressive drivers .20

Larson (1996) believes there are five common anger inducing beliefs that can be modified to reduce one's risk of road rage. These are; "make good time" where the driver believes it is necessary to drive to one's destination as quickly as possible within a certain amount of time. "Be number one" is based on the sense of competition and self-esteem that can be attained through dangerous behaviours such as racing at high speeds with another driver. "Try and make me" which represents a passive-aggressive belief about losing self esteem and status by giving into demanding drivers which can result in anger. "They shouldn't allow it" is a narcissistic belief that any driver that does not meet up to the individuals' standards of driving shouldn't be allowed to drive. Anger in this case results from perceived violations of those beliefs. Finally, "teach them a lesson" is a belief that one needs to punish other drivers who annoy, threaten or inconvenience them. Punishment can take its form in swearing, gestures, blocking another vehicle etc.

In summary, some existing interventions such as the graduated licensing system and a number of brief intervention approaches seem to have produced positive result in lowering adolescent risky driving behaviours; other interventions have not always shared in this success. However, in the light of new understandings of the neurobiological underpinnings of driving behaviour, especially in adolescents, it could be argued that what we need is more theoretically focussed approaches to tackle risky or aggressive driving. Existing interventions focus on a range of attitudinal and cognitive aspects of driving, but the really successful interventions of the future will need to take into consideration the neurobiological substrates underpinning driving behaviour, including the role of road rage as an important emotional component of dangerous driving (which could be modified using Cognitive Behaviour Therapy), the role of empathy as an aggression blocking mechanism (which could potentially be increased in males using Social Skills training), combined with an increased awareness of how the adolescent brain is being remodelled during these critical years. Such an approach could pay dividends in the future.

The perspective of evolutionary psychology .21

It is clear from the evidence that substantial differences between the sexes exist in the context of aggression, sensation-seeking and risk-taking and in tendencies toward rule violation. These express themselves in driving behaviour as much as they do in other areas of life. The remaining question concerns the origins of these clear differences.

The term 'evolutionary psychology' (EP) was coined by Barkow, Cosmides and Tooby (1987) and presented as a more coherent discipline in Cosmides and Tooby (1992). One of its major achievements has been to shift debate away from the old nature vs. nurture distinction in explaining individual and group differences to a focus on the roots of certain types of behaviour in terms of their evolutionary and adaptive functions and the cognitive mechanisms that underlie them.

To understand the relevance of EP in explaining differences between men and women in driving and related behaviours it is necessary to consider some of its essential principles. First, the brain is seen as being a physical system that functions much like a computer. Its circuits are designed to generate behaviour that is appropriate to environmental circumstances. Second, the circuits of the brain developed through natural selection to solve problems that our ancestors faced during our evolutionary history. Third, our 21st century skulls house essentially stone age minds.

The process of natural selection is slow and neural circuits require very long periods of time to develop and adapt. The conditions under which they developed were very different from those that surround us today. Well over 99% of our species' history has been spent in small hunter-gatherer societies – a pattern of life that Cosmides and Tooby describe as "a camping trip that lasted an entire lifetime, and this way of life endured for most of the last 10 million years." Our species lived as hunter-gatherers 1000 times longer than as anything else.

In essence then, our brains have not been designed specifically to deal with the very different kinds of social, environmental and agricultural conditions in which we now find ourselves. Our brains have not caught up with the very rapid shift away from the patterns of living that characterised our world until a mere 5,000 or so years ago. While young children show natural fear of snakes, they have to be taught to fear electrical sockets, even though the latter poses much more of a threat in modern urban environments.

From this perspective, we need to understand 'modern' types of behaviour as being predicated upon neural circuits that were of relevance to our success in hunting and gathering settings and which have not had sufficient time to adapt specifically to, say, driving motor cars. As Cosmides and Tooby comment:

"A necessary (though not sufficient) component of any explanation of behaviour – modern or otherwise – is a description of the design of the computational machinery that generates it. Behaviour in the present is generated by information-processing mechanisms that exist because they solved adaptive problems in the past – in the ancestral environments in which the human line evolved."

The perspective of evolutionary psychology .22

Evolutionary psychology does not pretend to answer all of the questions relating to complex and varying behaviours and patterns of interaction in modern settings. It does, however, take us forward in understanding what, on the surface, may seem to be irrational and self-defeating actions, such as driving fast in inappropriate road conditions or racing away from traffic lights before they have barely changed to green.

In early hunter-gather communities there were basic requirements for survival – physical protection and an adequate food supply. Those communities that were successful in achieving these conditions were able to reproduce at a faster rate than those who were not. Thus the genes that helped to shape the neural circuits that were the most effective in this sense were passed on in greater numbers.

To achieve an adequate food supply it was necessary to develop the skills for both hunting and for gathering wild fruits, nuts, etc to provide additional sources of nutrients. At the same time, children needed to be born and raised. Since women were often in a state of near permanent pregnancy and infant caring for most of their child-bearing years, a separation of roles between the sexes developed and males, with the additional advantage of slightly greater body size, took on the role of hunters while women took on the role of carers and gatherers.

From this point the neural circuits of men evolved to ensure appropriate skills for hunting – speed, spatial abilities, navigation to hunting grounds, etc. The circuits of women evolved to provide appropriate child-rearing, communication and social skills. This may sound very crude, but the legacy of such early developments is still apparent in known differences between the sexes in terms of visual-spatial and language abilities – see, for example, Blum (1997), Kimura (1999), Sapolsky (1999).

During the vast majority of our evolution it was also necessary to defend communities from potential attack from rival groups seeking hunting opportunities and access to an additional pool of women with whom to mate. In addition, the more an individual male could find sexual partners, the more his genes could be passed on to the future. So, basic patterns of aggression, calculated risk-taking and 'infidelity' among men arose as a 'natural' consequence of these basic requirements. Today, risk-taking men are still seen as more attractive by women – a more suitable opportunity to father their children who will be protected from the consequences of inappropriate engagement in risk primarily by women.

The account of the origins of basic human sex differences and the EP approach to explaining them is, of course, much more complex than this. It also needs to consider some of the moral and philosophical issues that the perspective generates – the 'biology is not destiny' argument in particular. (See Kenrick and Luce (2004) for a useful overview of recent developments in EP). It does, however, help us to see why male drivers are more at risk on the roads than females. Their 'stone age' brains which were moulded on the 'thrill of the chase', targeted aggression and a degree of 'lawlessness' – very effective in early hunter-gatherer communities – are not those that any sane person would design for dealing with the conditions on the

The perspective of evolutionary psychology .23

M40 motorway.

Evolution, of course, is a continuous and continuing process. Eventually the design of our neural circuits will catch up with the conditions that prevail now, rather than long ago in the past. Then, perhaps, we will see quite a different kind of male motorist. The only problem, of course, is that this will probably take a few million years.

There are clearly significant differences in the driving behaviour and accident proneness of male and female drivers. The big question is why? In this report we have considered some recent research on the neurobiological underpinnings of complex behaviours to try to understand possible sex differences in the organisation of the human brain and consider what possible insights this research may offer those specifically interested in driving. The report considers features like the role of empathy in different forms of social interaction, how male and female aggressive behaviours differ and how and why men and women engage in different forms of risk-taking behaviour. The report also considers how during the teenage years the brain goes through a process of remodelling and the effects this remodelling may have on the complex skills required for driving. The overall conclusions were that significant sex differences do exist and that some of the core processes mediated by these sex differences like empathy, undifferentiated aggression and the highs associated with certain types of risk will be causally connected to driving behaviour. These sex differences need to be understood in the context of human evolution and the differential pressures on men and women to succeed in different ways from an evolutionary point of view. For example, empathy may be a core skill in the development of female types of indirect aggression and may be a precursor for reciprocal bonding in the female social group, but may be less important for male aggression where successful positioning in a dominant hierarchy might be the most significant outcome. Consideration of these neurobiological differences, and the evolutionary pressures behind them, might allow us to devise much more effective intervention programs which start from the assumption that men and women come to driving not as tabula rasa but as complex sophisticated hard-wired organisms with a formidable history of human evolution behind them. Intervention programs should recognise such differences rather than attempting to ignore them.

With driving therefore, the aim of intervention, which, of course, is designed to reduce errant behaviour and therefore accidents, injury and death among road users, should be to change the responses of individuals so that they do not always operate in an instinctive fashion, driven by their hard-wired nervous systems. If males do drive aggressively, they do so partly because of their evolutionary make-up, so society must aim to use education to help individuals suppress what might be their most natural responses when behind the wheel. Driving is, after all, a cooperative activity involving all road users rather than a competitive activity, reinforced and supported through evolutionary processes.

Of course, much new research in neuroscience needs to be carried out before we can fully appreciate all of the basic differences that separates the male and female brain but the research that we already have available suggests that there are striking structural and functional differences which will affect driving and much else besides and this must be a good theoretical starting point in trying to deal with the high accident rate of male drivers in general, and young male drivers in particular.

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