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Traffic rules and traffic safety

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Abstract

In the present paper the effects of traffic rules on driver behaviour and on traffic safety are discussed. The discussion is mainly based on research concerning driver's use of safety equipment, their speed adjustment and drunken driving with respect to safety potential, effects of the rules, and effects of enforcement on driver behaviour. Factors influencing drivers' decisions to comply with rules are also considered. It is concluded that only rules that are possible to enforce should be implemented and that police surveillance should be visible to the drivers. Also, the traffic system should be seen as a social system where drivers are interacting with other drivers and road users. Rules and regulations are important to help the actors of the system to function in a safe and effective way. © 1998 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Ever since the motor vehicle became a common means for transportation, road traffic has been regulated by a network of rules and regulations. Many rules are necessary for the mobility of traffic but, especially after the Second World War, there has been a growing number of rules implemented to improve traffic safety. Today, there are few areas of human activity that are as regulated by legal restrictions as the traffic system. Therefore, experiences of driver behaviour, with regard to rule compliance, should be of value for regulations of behaviours in other disciplines. However, in spite of the long experience of rules for better safety in traffic, drivers' behaviour is far from safe. For example, it has been estimated (Evans, 1991) that world-wide more than half a million people are killed each year in traffic accidents. In more than 90% of these accidents unsafe behaviour of the road users is a sole or contributory factor (Rumar, 1985). Therefore, in a discussion of safety rules it should be remembered that although much is known about traffic rules there is still much to learn about their effect on driver behaviour.

The purpose of the present paper is to discuss the effects of traffic rules on driver behaviour and traffic safety. As most traffic rules that have been investigated concern vehicle drivers this term is used throughout the text, even if sometimes it would be more appropriate to use the words road user. The discussion will be based on examples from literature and from our own research. Three areas of behaviour are used to illustrate effects of rules: drivers' use of safety equipment, their speed adjustment and drunken driving. Rules to promote safety in these behaviours are probably the most frequently investigated rules of traffic. The rules vary in ease of compliance detection. The safety potential, effects of the rules, and effects of enforcement on behaviour will be reviewed. Factors influencing drivers' decisions to comply with rules will also be discussed.

2. Rules to promote the use of safety restraints

There is general agreement that the use of safety belts by a driver and passenger(s) in a car is an effective measure to decrease risk of injury in case of an accident. For example, the risk of a fatal accident decreases by about 40–50% for drivers using a safety belt (Elvik et al., 1989; Evans, 1991).

Modern cars are equipped with safety belts for all car users and a great deal of resources have been invested in information campaigns to promote the use of safety belts. However, several investigations indicate that the result of these efforts, without any mandatory law, is a frequency of use of about 30–40% (Elvik et al., 1989; Evans, 1991). In Sweden, in 1971, seat belts were used by only 15% of drivers. Massive campaign efforts, between 1971 and 1974, promoting the usage of seat belts, increased the number of users to 35%. However, when seat belt usage was made mandatory in 1975 the effect was an immediate increase in usage from 35% in 1974 to 85% in 1975 (Dahlqvist, 1992). Similar or even more impressive results have been reported from other countries (Evans, 1991; Mäkinen and Hagenzieker, 1991). A clear example of the effect of seat belt legislation on behaviour is reported from Alberta in Canada (Grant, 1991). Here, seat belt use was made mandatory in 1987 with usage rising from 28–83%. However, it dropped to 45% in 1989 when the law was declared invalid. When the seat belt law was accepted by a higher court in 1990 the wearing rate again rose to 88%.

When a new law is implemented the population is normally informed about the new legislation through information campaigns and police enforcement against violations of the law. Therefore, the effects of the rule and the effects of the enforcement are difficult to separate. According to Grant (1991), enforcement of the seat belt wearing law is critical for the success of the new rule. In Germany the use of safety belts increased from about 60% with compulsory use without sanctions, to over 90% usage when sanctions were imposed (Heinrich, 1991). In a review, Hagenzieker (1991) concludes that enforcement increases belt usage by about 20–25%.

Another example of rules promoting safety is the use of helmets in traffic. According to Evans (1991), the wearing of helmets in cities without a law has been found to be around 35–50%. In cities with a law it is 100%. The fatality risk

decreases by about 20% for a motorcyclist if he wears a helmet. In Norway, before a mandatory law the wearing rate was about 60%. After imposition of a law the rate went up to 75–90% and when sanctions were added the rate became close to 100% (Elvik et al., 1989).

The wearing of helmets by moped riders, i.e. riders of light motorcycles with maximum speed limited to 30 km/h, became mandatory in Sweden in 1978. Today, most moped riders (mainly males between 15 and 18 years) are wearing helmets, although there are no official reports of observed use. As a contrast, due to alarming reports about head injuries among cyclists, there has been several Swedish campaigns to promote the use of helmets by informing cyclists about the danger of riding a bicycle without head protection. The risk to a cyclist is similar to that of a moped driver; both are unprotected road users and they are travelling within the same speed interval. Light comfortable helmets are available on the market for cyclists. In spite of the campaigns, recent observations of helmet use among adult Swedish cyclists show a wearing frequency of less than 4% (Nolén, 1992).

3. Effects of rules against excessive speed

Several evaluations of decreased speed limits show that reductions of mean speed reduce the number of accidents with personal injury (Elvik et al., 1989). Chosen speed has been calculated to have a large influence on accidents (Nilsson, 1984). Accident rate is related to change of mean speed in direct proportion, but injuries or fatalities increase at an even faster rate. Decreased mean speed as a consequence of speed limits can, therefore, be expected to increase the safety of car users.

There is general agreement in the literature that imposition of speed limits reduces the proportion of vehicles travelling at high speeds (Elvik et al., 1989; Evans, 1991). For example, when the 55 mph (88 km/h) nation-wide speed limit was introduced in the US in 1974, average rural interstate speeds, which previously had 70 mph (112 km/h) speed limits, decreased from 63.4 to 57.6 mph, and when the limits were increased from 55 to 65 mph (104 km/h) in 1987 there was an average increase in speeds from 60.8 to 62.2 mph (Evans, 1991). One effect of decreased speed limits is an increase in proportion of speeding drivers (Elvik et al., 1989). Salusjärvi (1981) showed that very high speed limits increased speeds of previously low speed drivers. Although posted speed limits affect driver speed adjustment, the average compliance is not so high. According to recent data from Swedish roads, dependent upon road status, between 37 and 85% of drivers drive faster than the posted speed limits (Nilsson, 1991).

There is also general agreement that police surveillance has an effect on driver speed adjustment (for reviews see: OECD, 1974; Rothengatter, 1982; Armour, 1984). Both speeders and non-speeders have been observed to slow down in the vicinity of a police unit. Immediate effects of enforcement are noticeable for about 5 km from the enforcement spot and the effects last for 10–14 days. A Swedish study (Nilsson et al., 1983) investigated long-term effects of 2 years of intensified enforcement on speeding on roads with a 90 km/h speed limit. It was found that an increase of the enforcement to three to five times of the normal level was necessary to affect

speeds of commuting drivers driving faster than 105 km/h. Similar results have been reported from Finland. During a police strike, with no enforcement; there was no change in mean speed but the proportion of drivers going faster than 10 km/h over the limit decreased (Summala et al., 1980).

Most studies reviewed concern the effects of enforcement on rural roads. Åberg and Haglund (1989), however, observed vehicle speed on four urban roads with temporary speed reductions from 50 to 30 km/h. Two of the roads had been subject to surveillance by police radar units about once a year during a 5-year period. On the remaining roads there had been no control at all during that time. The mean speed on the non-enforced roads was reduced from 51.9 to 42.8 km/h as an effect of the lowered speed limit, while the speed was reduced from 55.2 to 36.4 km/h on the roads with enforcement. This result suggests that the effects of enforcement might vary with the rule that is enforced. It is easier to obtain changes in driver behaviour on urban roads than on highways.

4. Rules against drunken driving

According to Evans (1991), alcohol exceeds by far any other single factor as a cause of traffic accidents. The crash risk increases steeply with increasing blood alcohol concentration (BAC) and Nilsson (1986) reports that the risk at 0.05% BAC is four times higher than that of a sober driver, at 0.10% BAC the risk is 12 times higher and at 0.20% BAC the risk has increased to 300 times the level of a sober driver.

Today, most countries have implemented laws against drunken driving and typical limits vary from 0.05 to 0.10% BAC. Ross (1984) reports on the effects of the introduction of BAC limits in different countries, such as UK, Canada, New Zealand and The Netherlands. Generally, the estimated number of drunken drivers and the number of fatalities are reported to decrease as a result of the new law.

Elvik et al. (1989) conclude that the effect of new laws against drunken driving will not be long-lasting unless the laws are followed by an increased probability of detection. A Swedish study (Åberg et al., 1986) showed that increased random breath testing increased perceived probability of detection. Also, the number of detected drivers and the number of intoxicated drivers in accidents decreased.

According to Vingilis (1983) and Dannerstedt et al. (1986) the drunken driver population consists of overlapping but different sub-populations. The majority of drunken drivers are 'social drinkers', while the 'high-risk' group involved in collisions and accidents are to a large extent 'problem drinkers' or alcoholics. This might be a problem as problem drinkers are believed to be less responsive to legal measures than social drinkers.

The brief summary of research presented, concerning three selected areas of traffic safety rules, shows clearly that rules and regulations can increase safety by changing behaviour. It is also clear that information about risks has a very limited effect on behaviour unless it is combined with legal measures. For large and lasting effects of rules, police enforcement and sanctions are necessary.

Different rules differ in their effect on driver behaviour. For examples, rules to promote the use of safety restraints lead to higher compliance than rules to decrease

speed limits, and responses to compulsory use of motorcycle helmets are better than responses to mandatory use of safety belts. Research about drunken driving points to the problem of differences between drivers. Possible explanations of the differences among rules and groups of drivers will be discussed in the following sections of this paper.

5. Why are traffic safety rules necessary?

From the examples of the effects of rules on dangerous behaviours it can be concluded that a driver, by keeping sober, wearing a safety belt and avoiding excessive speed, can increase chance of avoiding accidents a great deal compared with a less cautious driver. It is difficult to understand why traffic safety rules should be necessary to change behaviour. If they were behaving in a rational way, drivers who learn that their behaviour is associated with increased risks should avoid performing that behaviour and then traffic safety rules would not be necessary. However, there is plenty of evidence, also from other fields than that of driver behaviour, indicating that information about risky behaviours has very little effect on actual behaviour (e.g. Elvik et al., 1989).

The fact that drivers do not respond to information about the dangers of traffic might depend on how the risks are perceived by them. Although traffic accidents cause a great deal of premature deaths in society today, the probability of being involved in an accident is very small for most drivers. The likelihood of a driver being involved in a fatal accident is considerably less than once in 1000 years, and for accidents involving an injury, less than once in 100 years (Rumar, 1985). Most drivers are very seldom confronted with the dangers of traffic and, if they are, they might not be able to recognise the risk (McKenna, 1985). On the contrary, in their daily driving drivers have plenty of opportunities to learn through their own experience that the risks of traffic are very small. The high risks of driving often announced in information campaigns will be interpreted by drivers to be true in general but not for themselves in particular. Therefore, the function of traffic rules is to provide drivers with new risks, with higher probabilities, than the ordinary safety risks of traffic. The risk of being detected while violating the rule must be perceived as high enough to ensure compliance. The effects of rules and sanctions on perceived probability of detection will be discussed in the next section.

6. Perceived probability of detection

According to the previous review, enforcement is needed to increase the effects of safety rules and must be visible to be effective. In an investigation of increased police surveillance on speeding behaviour, high-enforcement roads were compared with low-enforcement roads (Nilsson et al., 1983). An increase of three to five times the normal level of enforcement was needed to slow down speeding drivers. Normal enforcement level means that a driver, who is speeding every time when driving a car, can expect to be detected once in 3 years (Nilsson and Engdahl, 1986). This

probability of detection is quite small but still considerably higher than the probability of an accident. It was also found that drivers on high-enforcement roads reported significantly higher perceived probabilities of detection than drivers on low-enforcement roads. Thus, even a relatively small change in probability of detection could be perceived by drivers.

Similar results were obtained in a study of the increased use of breath tests by the police (Åberg et al., 1986). A comparison was made between drivers from two Swedish counties, one county with a high frequency of breath tests, about 0.3 tests per licensed driver each year, and one county with few tests, about 0.1 tests per licensed driver. The increased use of tests covaried with fewer drunken drivers, fewer accidents involving drunken drivers and an increased level of perceived probability of detection. The results of this study suggest that personal experience of enforcement is much more effective in increasing perceived probability of detection than information about the experiences of others. Another finding was that drivers can learn where and when there is enforcement and, also, which behaviour the police is enforcing.

The results discussed in the present paper clearly indicate that increased perceived probability of detection is a necessary condition for increased rule compliance. The results cannot directly explain the difference in compliance observed for different rules. However, the wearing of helmets or the use of safety belts are more conspicuous than speeding or drunken driving. For the latter behaviour the police need special equipment to be able to enforce, while it is very easy to detect a motorcycle rider without a helmet. The results of a US investigation (Escobedo et al., 1992) support the hypothesis that compliance is better for behaviours that are easy to enforce. Some states with mandatory seat belt laws have secondary police enforcement; a driver must be stopped for some other violation before a citation or fine for a failure to use a safety belt can be imposed. The average self-reported frequency of safety belt usage in these states is 49%, which is more than in states without a law (35%) but less than in states with primary enforcement, where safety belt usage is 70%.

The effectiveness of new laws in changing behaviour depends to a great extent on drivers' perceived probability of detection which depends on the rule that is implemented, the amount of police surveillance and the sanctions imposed in case of violations. However, there are other factors that are assumed to influence drivers' law abidance, e.g. attitudes and social norms. Many researchers (e.g. Reason et al., 1990) suggest that violations require explanations in terms of social and motivational factors. In the following section effects of attitudes and social norms on violations of traffic rules will be discussed.

7. Effects of attitudes and social norms on rule compliance

Although not all violations in traffic can be considered volitional, many decisions to break the law are made deliberately. Several attempts have been made to study the influence of attitudes and social norms on drivers' decision making in traffic, using the Ajzen and Fishbein (1980) theory of reasoned action.

According to the theory, the best predictor of behaviour is the intention to behave in a certain way. The intention is determined both by attitudes towards behaviour and by social norms connected to behaviour. The attitudes are built up by the sum of products between expectations and evaluations of different outcomes of behaviour. In a similar way, the social norms are constructed from expectations and evaluations concerning social values. The theory, and later developments of the theory (e.g. Ajzen, 1991) have also generated several investigations in the area of traffic safety. For example, Jonah and Dawson (1982) studied seat belt use, Vogel and Rothengatter (1984) investigated reasons for speeding and Åberg (1998) studied drunken driving. The results from these and other investigations suggest that the Ajzen and Fishbein model is appropriate for analyses of factors affecting rule compliance.

In a study of drunken driving, performed in 1987 (Åberg, 1993), it was shown that attitudes and social norms were important for the decision of Swedish male drivers to drive after alcohol consumption. However, the Swedes, in general, had extremely negative attitudes against drunken driving. In a study of drivers' self-reported behaviour, drinking and driving was the violation that was reported least frequently, while speeding was reported as the most frequent violation (Åberg and Rimmö, 1998). A causal analysis (LISREL—a statistical program for structural equation modelling; Jöreskog and Sörbom, 1989) showed that attitudes are important for drunken driving decisions and that evaluations of sanctions affect attitudes more than, for example, evaluation about consequences of accidents. The evaluations were highly intercorrelated. Furthermore, according to the analysis, social norms were correlated with both attitudes and evaluations and it is argued that social norms should precede evaluations and attitudes in the causal chain explaining behaviour. Among background variables the influence of drinking habits is so strong that no other variables, such as age or driving habits, are needed to improve the model.

The causal structure obtained was tested in a cross-cultural comparison concerning drunken driving in Denmark, Norway and Sweden (Åberg et al., 1990). The same structure could be used for the different national samples in spite of the fact that drinking and driving is much more frequent in Denmark than in Sweden and Norway. It has been estimated that about 0.1 to 0.2% of drivers in Norway and Sweden have a BAC over 0.05%, while in Denmark this proportion is about 1.2%. In Denmark the drivers had less negative attitudes and social norms and evaluated sanctions as less negative than drivers in the other two countries. There were no important differences in drinking habits among the countries.

It should be noted that measures of expectations about sanctions, i.e. perceived probability of detection, did not improve the causal model. However, for some of the study subjects it was possible to ask questions about important factors at two different decision situations: the last time the driver decided to drive after drinking, and the last time they decided not to drive. When they decided to drive it was because factors such as a need for the car the next day or a lack of other available facilities for transport were most important. When they decided not to drive it was shown that factors such as risk of detection and sanction, or a risk of hurting other

people in case of an accident were most important. Thus, the perceived probability of detection was not unimportant but varied with the situation rather than with individuals and, therefore, it did not fit into the causal model when based on individual variation.

In 1990 the BAC limit in Sweden was decreased from 0.05 to 0.02%. One year after the change of the law a new investigation of attitude structure and self-reported behaviour of Swedish drivers was made (Åberg, 1993). The same structure of intentions, attitudes, social norms, etc., as in the 1987 study was obtained. The drivers also reported the same drinking habits and frequencies of drunken driving behaviour, but they predicted that the number of violations of the law would increase in the future. There was also a small but significant change towards less negative attitudes against drunken driving. Social norms or evaluations of sanctions and consequences of accidents did not change. What did change was the perceived probability of detection that decreased with the new law. It should be emphasised that the law did not change the drunk driving behaviour, only compliance with the law.

In a study of speed adjustment (Haglund and Åberg, 1998), vehicle speed was measured on road sections with speed limits of 70 or 90 km/h. After passing the measurement point the vehicles were stopped by a police officer and a short interview was made by researchers. After this interview the drivers were asked to accept a questionnaire which they should answer and mail. Questions about behaviour, intentions, attitudes, social norms, etc., were asked. The results showed that it was possible to 'predict' observed speed from intentions and that these intentions were correlated with attitudes. The attitudes had higher correlations with risk of accident than with risk of sanctions. The social norms did not fit into the causal network for speed adjustment.

The attitude structure was found to be different for drunken driving compared to speeding and, also, the strength of the attitudes was different. Of the drivers, 99% were very negative towards driving with a BAC over the limit while only 22% of the drivers were very negative towards driving 10 km/h over the 90 km/h speed limit. One important difference between the two attitudes is the influence of social norms. In drunken driving the social norms are important for evaluations of sanctions, attitudes and intentions. Such an influence of norms could not be found among factors affecting drivers' decisions to speed or not. As has been mentioned before, the drunken driving law was recently changed in Sweden. However, there is still a debate going on and several arguments are in favour of a zero BAC limit. At about the same time, the authorities discussed a general decrease of speed limits of 10 km/h. The opposition against decreased speeds was very strong and the arguments presented were rather in favour of increased speed limits. Among researchers there is a general agreement that accident reduction would be much greater for decreased speed limits than for decreased BAC limits. Thus, the rules differ with respect to their social acceptance in the population, and this may be related to the influence of social norms in the attitude structure explaining drunken driving. The influence of social factors on behaviour in traffic safety research has only recently been recognised to any extent (e.g. Rothengatter, 1990; Evans, 1991). This problem is also connected to how drivers are influenced by the way other drivers behave (e.g. Zaidel, 1992; Connolly and Åberg, 1993).

8. What can be learned from experiences of traffic safety rules?

Even if only a few of all the different traffic safety rules have been discussed in the present paper it should be possible to extract some information about rule compliance in general. An initial, almost trivial, conclusion is that safety rules must concern behaviours that are unwanted from the drivers' own views or from the views of other drivers or authorities. Another trivial comment is that drivers must have knowledge about the rules and perceive them as reasonable to be able to follow. There are examples of rules that are difficult to apply in reality. For example, one very strict rule in Sweden is the right-of-way for drivers coming from the right hand side in a crossing situation. Even if all drivers have a general knowledge about the rule they have great difficulties in applying this knowledge in real traffic situations. Therefore, in many situations, informal rules have been developed that are accepted by most drivers and the interaction among drivers is, most of the time, without problems in spite of the formal rules (Helmers and Åberg, 1978). A rule that is easier to follow and seems more reasonable should be more appropriate in this case.

A further conclusion is that rules in traffic are necessary because, generally, drivers cannot be expected to learn about the negative consequences of behaviour through their own experiences. Attempts to inform drivers about the risks of traffic, via mass media information or education, have not been very successful. Rather, the drivers learn through their own experience that it is possible to break the rules without encountering aversive consequences. To prevent this negative learning it is necessary to enforce the rules, for example by police surveillance, and to impose sanctions for violators of rules. One consequence of this is that only rules that are possible to enforce should be implemented. Behaviours that are difficult to register are also difficult to enforce and, therefore, cannot be expected to be changed by rules and regulations. Police surveillance should be visible to drivers so that they can learn about it order to increase their perceived probability of detection, which is an important subjective factor in driver decision making.

Finally, the traffic system should be seen as a social system where drivers are interacting with other drivers and road users. Rules and regulations are important to help the actors of the system to function in a safe and effective way. Drivers' attitudes towards rules and the social norms concerning compliance with rules are important for an understanding of the differences between drivers as well as differences between groups of drivers. Some of the results discussed suggest that social norms have a causal influence on both evaluations of consequences of, and attitudes towards, violations of rules. However, more research is needed before the effects of social factors on rule compliance can be understood.

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