The long-term effects of an ISA speed-warning device on drivers’ speeding behaviour

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Abstract

Different systems of intelligent speed adaptation (ISA) have already been tested in the field and large-scale implementation is being discussed. But do we really know how these systems affect drivers during long-term use? Between 2000 and 2003 a total of 61 test drivers had an ISA speed-warning device installed in their vehicles. Data from these trials show that, initially, the device greatly reduced the amount of time the majority of test drivers spent above the speed limit, and to some extent also reduced their mean speeds, but this effect decreased with time. Further analyses of 27 of the 61 test drivers then showed that the activation of the warning system affected different drivers in quite a homogenous way, with regards to attitude, subjective norm and self-reported behaviour, but not with regards to perceived behavioural control. After activation, long-term use did, however, affect the test drivers in a homogenous way with regards to attitude, subjective norm and self-reported behaviour, as well as perceived behavioural control. When considering these results it must be remembered that the device tested was a first generation ISA speed-warning device and with more research we think that different ISA-systems could be improved and the effects made more stable during long-term use.

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1. Introduction

Both lower speeds and a more homogeneous speed distribution are important factors in traffic safety. According to Nilsson (2000) the ratio of change in accident rate is proportional to the ratio of change in mean speed raised to a power – where the power is related to the consequence of the accident (injury, severe injury or fatal injury). By this follows that a decrease in mean speed results in a larger decrease in fatal accidents compared to accidents with severe injuries, and in a larger decrease in accidents with severe injuries compared to accidents with less severe injuries. With regards to speed distribution several studies have shown that most accidents in rural areas involve drivers who are either driving much faster or much slower than the mean traffic
speed, which means that the relationship between accident involvement rate and the deviation from the mean traffic speed is U-shaped (Finch, Kompfner, Lockwood, & Maycock, 1994; for a review). Hauer (1971) showed that the relationship between the rate at which overtakings take place (either overtaking someone or being overtaken yourself) and the deviation from mean traffic speed is also U-shaped and that these two curves correspond strongly. The U-shape of the accident involvement curve can therefore, at least partially, be explained by the rate at which overtakings take place. It has also been shown that a large variation in speed may lead to more drivers feeling hindered in their driving leading to increased irritation (Björklund, 2005) or anger (Defenbacher, Oetting, & Lynch, 1994). According to Defenbacher et al. (1994), literature on the influence of emotion on performance show that both perception and information processing can be negatively influenced by emotional arousal. It is therefore reasonable to believe that whilst angry, a driver is less suited to driving.

Previous research has shown that intelligent speed adaptation (ISA) has a potential to both lower the speeds and to create a more homogeneous speed distribution (Almqvist & Nygård, 1997; Brookhuis & De Waard, 1999; Duynstee, Katteler, & Martens, 2001; Hjälmdahl, Almqvist, & Várheleyi, 2002; Regan et al., 2005; Várheleyi, Adell, & Hjälmdahl, 2005; Várheleyi, Hjälmdahl, Hydén, & Draskóczy, 2004; Várheleyi & Mäkinen, 2001). Intelligent speed adaptation is the name of different in-vehicle systems aiming to help drivers adapt their speeds to a static or dynamic speed limit. These systems range from advisory to intervening. Advisory systems convey information about the current speed limit to the drivers and warn them, by audible, visible, or haptic means, if this limit is exceeded. It is, however, still up to the drivers whether to use or ignore this information. Intervening systems affect the vehicles and may go as far as making it impossible for the drivers to exceed the speed limit. The first study with an in-vehicle speed adaptation system was carried out in the beginning of the 1980s in France and since then extensive research, including several simulations and field trials, has been conducted (Carsten, 2002; Hjälmdahl, 2004; Jamson, Carsten, Chorlton, & Fowkes, 2006; Wallén Warner, 2006; for reviews). The effect of intelligent speed adaptation is promising. The Swedish large-scale field trials, funded by the Swedish Road Administration between 1999 and 2002, showed a decrease in speed violations at all speed limits and it was estimated that the number of people injured in traffic could be reduced with as much as 20–30%, if everyone had an ISA-device installed in their vehicles (Swedish National Road Administration, 2002). In the Australian TAC SafeCar project it was estimated that serious injury accidents would be reduced with 7% and fatal accidents with 9% if a system, combining visual and audible warnings with a counterforce in the acceleration pedal making it harder than normal to exceed the limit, was implemented on a large-scale (Regan et al., 2005). Finally, in the British external vehicle speed control (EVSC) project it was predicted that injury accidents would be reduced with 20% and fatal accidents with 37% if all vehicles were fitted with a system that limited the vehicles’ speed to the posted speed limit. If the system also lowered the speed further in case of, for example, slippery roads or major traffic incidents, injury accidents would be reduced with 36% and fatal accidents with 59% (Carsten & Tate, 2005). With this as a background it is not surprising that large-scale ISA-implementation is now being discussed as an effective way to increase road safety.

The results do indeed sound very promising but in reality it is very difficult to predict which effect implementation of different safety measures would have. In the UK, for example, the Department of Transport estimated that 1000 deaths per year would be saved if seat belt wearing was made compulsory. However, after implementation measurements showed savings “in excess of 200 deaths” (Grayson, 1996, p. 11). Whether the disparity was due to difficulties in predicting and measuring casualty benefits or due to behavioural changes (e.g. drivers increased their speeds because wearing of a seatbelt made them feel safer) can be discussed – but in either case it shows how difficult it is to predict future safety benefits. It is therefore very important that we gain as much knowledge as possible about the effects of different intelligent speed adaptation systems before investing huge sums of money on large-scale implementation. One of the things we need to gain more knowledge about is the long-term effects of intelligent speed adaptation.

The Swedish large-scale field trials, mentioned above, were conducted in four Swedish cities, and approximately 4500 vehicles participated in these trials. The cities differed with respect to the number of test vehicles as well as the devices used (Swedish National Road Administration, 1999, 2002). In Borlänge, an ISA speed-warning device was used. This device continuously informed the drivers of the current speed limit and warned them, with a flashing red light and sound signals, if they exceeded this limit. In addition, the device continu-
ously logged the drivers’ behaviour with regards to speed and position, amongst other variables. In Lund, the device used was an active accelerator pedal, which exerted a counterforce at speeds over the speed limit. This meant that the driver had to press the pedal three to five times harder than normal in order to exceed the speed limit. The results from Lund showed a decrease in speed as well as in speed variation but the initial effect of the device was greater than the effect after long-term use. The increase in speed during the period between 1 month (short-term use) and 5–11 months (long-term use) after activation of the pedal was 5–50% of the decrease between the period before activation and 1 month after (Hjälm Dahl et al., 2002; Várhelyi et al., 2004).

But why did the effect of the active accelerator pedal decrease with long-term use and is the same true for other types of ISA-systems? In 2002, at the end of the Swedish national trials, a number of test drivers in Borlänge chose to continue driving with their ISA speed-warning devices installed in their vehicles. This created a unique opportunity to study the long-term effects of an ISA speed-warning device. In addition, the test drivers answered several questionnaires including questions based on Ajzen’s (1991) theory of planned behaviour. This made it possible to examine whether the test drivers had, for example, changed their attitudes towards speeding and/or if they found it easier to comply with the speed limits after long-term use of an ISA speed-warning device.

The theory of planned behaviour has previously been successfully used to predict such diverse behaviours as choosing a career, smoking or deciding to use condoms, among many others (Ajzen, 2001; Armitage & Conner, 2001; Sutton, 1998; for reviews). The theory has also been used in traffic safety research as a frame of reference to explain and/or predict drivers’ speeding behaviour (Åberg, 1997; Elliott, Armitage, & Baughan, 2003, 2005; Forward, 1997; Letirand & Delhomme, 2005; Newnam, Watson, & Murray, 2004; Parker, 1997; Parker, Manstead, Stradling, & Reason, 1992a; Parker, Manstead, Stradling, Reason, & Baxter, 1992b; Stradling & Parker, 1997; Vogel, 1984; Wallén Warner & Åberg, 2006). The theory of planned behaviour is an extension of the theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). This extension was made due to the original model’s limitation in dealing with behaviours over which people have incomplete volitional control. According to the theory of planned behaviour (Ajzen, 1991) people’s attitude towards the behaviour, their subjective norm, and their perceived behavioural control determine their behaviour indirectly via their intention. The more positive a person’s attitude and subjective norm is, and the greater their perceived behavioural control, the stronger is their intention to perform the behaviour. Finally, given enough actual control over the behaviour, people are expected to carry out their intention as soon as an opportunity is given. For behaviours over which people have incomplete volitional control it is also useful to consider perceived behavioural control as a codeterminant (together with intention) of the behaviour. The relationship between perceived behavioural control and behaviour is however dependent on the accuracy of people’s perception of their control over the behaviour.

Even though many studies with intelligent speed adaptation have been conducted, the large majority of these studies have been limited in time. As the effect of newly implemented systems might change over time further research is needed to examine drivers’ speeding behaviour after long-term use of the systems. If it is found that the effect changes over time it is also of interest to examine what causes these changes. The first aim of the current study is therefore to examine drivers’ speeding behaviour after long-term use of an ISA speed-warning device. The second aim is to try to understand what caused possible behavioural changes by examining the variables in the theory of planned behaviour.

2. Method

During the large-scale field trials with ISA, funded by the Swedish Road Administration between 1999 and 2002, an ISA speed-warning device was installed in approximately 400 vehicles (250 private, 150 commercial) in the city of Borlänge. The device was, in principle, a navigation system based on a digital map covering approximately 700 km of roads within the city of Borlänge and four main roads leaving the city. Using GPS, the device continuously monitored where the vehicle was and with which speed it was travelling. This information was then compared with the digital map that included speed limits, and the test drivers were informed of the current speed limit at their present position. If the speed limit was exceeded the test drivers were warned with a flashing red light and sound signals. In addition to this, the device continuously logged
the test drivers’ behaviour and by using GSM technique the logged data was collected from the vehicles. The data were then gathered and stored in a central Microsoft SQL-server database (version 7.0) where analyses could be performed. For further technical description see Myhrberg, Holting, and Brus (2002).

2.1. Test drivers

In 1999 private test drivers were recruited among 1000 randomly selected car owners (with cars no older than from 1984) in the city of Borlänge. Approximately 1 year later a new recruitment was made amongst an additional 2000 randomly selected car owners in the area. A total of approximately 250 private car owners and their co-drivers (other family members that regularly used the vehicle) chose to participate in the project. The test drivers participation was purely voluntary and they did not receive any rewards.

In 2002, at the end of the national trials, a number of test drivers in Borlänge chose to continue driving with the devices installed in their vehicles. Their participation was still purely voluntary without any rewards or enforcements. Data for the current study were collected from a total of 61 test drivers, who were the main users of the vehicle in the household and had logged data registered on roads with 50, 70 and 90 km/h speed limits from four different time periods. Even data in streets with a 30 km/h speed limit and on roads with a 110 km/h speed limit were registered, but that data is not included in the current study. The first of the four periods was during 2–4 weeks in the autumn of 2000 to the spring of 2001, depending on when the test driver had the ISA speed-warning device installed in their vehicle. During this period the warning system was not yet activated which means that the test drivers did not receive any information about the current speed limit or any warning signals if this limit was exceeded, but their speeding behaviour was still logged. The second period was during 4 weeks in the autumn of 2000 to the spring of 2001. During this period the warning system had just been activated and the test drivers received information about the current speed limit as well as warning signals if they exceeded this limit. The third period was during May–July 2001 (approximately 35% of the test drivers had their warning systems activated during April or May 2001 which means that their data from the period after activation overlaps somewhat with the data collected during the spring of 2001) and the last period was during May–July 2003.

The test drivers were also sent several questionnaires. Unfortunately only 27, out of the 61 test drivers described above, completed all three questionnaires distributed in March 2000 (before the warning system was activated), December 2001 and June 2004 (when they were still driving with the ISA speed-warning device installed in their vehicles).

At the start of the trials in 2000, the 61 test drivers’ age ranged from 27 to 79 years, with a mean of 56 years. Seventy-two percent of the test drivers were men while 28% were women. The skewed distribution can to some extent be explained by the fact that 68% of the total number of car owners in the Borlänge municipal area are men, and the car owners’ average age is 50 years (H. Granlund, Swedish Road Administration, personal communication, December 11 2003). Mann–Whitney U-tests showed that the 27 test drivers (who had completed all three questionnaires) did not differ from the other 34 test drivers as far as age, gender, number of trips, mean speed and time spent speeding was concerned.

2.2. Procedure

2.2.1. Logged behaviour

The test drivers’ behaviour (speed, position, etc.) was logged at least once every 10 s as soon as the vehicles were driven within the area covered by the digital map used by the ISA speed-warning device. To give the test drivers some margin, the measure of speeding behaviour was taken as the quotient of the total time exceeding the speed limits by at least 2 km/h and the total time driven. The speeds measured by the device were all based on the vehicles actual speeds measured by the GPS. These speeds did not necessarily correspond to the speeds shown on the vehicles speedometers. This is due to the fact that most car manufacturers use a margin so that the speed shown on speedometers is somewhat higher than the vehicle’s actual speed. The size of this margin differs between brands but on average the speedometers in most of the test drivers’ vehicles showed a speeding rate of approximately 7 km/h when the ISA speed-warning device measured a 2 km/h excess in speed.
2.2.2. Questionnaires

The first questionnaire, included in the current study, was posted to the test drivers in March 2000 after they had the device installed in their vehicles, but before the warning system was activated. The second questionnaire was posted in December 2001 after the test drivers had driven with the warning system activated for 7–14 months (depending on when the test drivers first had the ISA speed-warning device installed in their vehicles) and the third questionnaire was posted to the test drivers in June 2004 after they had driven with the warning system activated for 37–44 months (again depending on when the test drivers first had the ISA speed-warning device installed in their vehicles). The three questionnaires included questions with Ajzen’s theory of planned behaviour as a frame of reference. Several sections dealing with other aspects of speed and road safety were also included, but these issues will not be addressed here. All questions were asked for 50 km/h in urban environments, 70 km/h in urban environments, 70 km/h in rural environments and 90 km/h in rural environments.

Attitude towards the behaviour (A) was measured by asking: “How acceptable is it for you personally to exceed different speed limits? \( X \) km/h in urban/rural environments?” 1 = not acceptable; 3 = neither; 5 = totally acceptable.

Subjective norm (SN) was measured by asking: “What do you believe people important to you (family, close friends, etc.) think if you exceed speed limits? \( X \) km/h in urban/rural environments? 1 = not acceptable; 3 = neither; 5 = totally acceptable.

Perceived behavioural control (PBC) was measured by asking: “How hard is it to comply with different speed limits? \( X \) km/h in urban/rural environments? 1 = very hard; 3 = neither; 5 = very easy.

Self-reported speeding (S-R S) was measured by asking: “If you consider your own behaviour as a driver. How often do you exceed the speed limit \( X \) km/h in urban/rural environments by 10 km/h or more?” 1 = never; 2 = very rarely; 3 = rarely; 4 = sometimes; 5 = often; 6 = very often.

According to the theory of planned behaviour (Ajzen, 1991) people’s attitude towards the behaviour, their subjective norm, and their perceived behavioural control determine their behaviour indirectly via their intention. In the current study the test drivers received the first questionnaire just before the ISA speed-warning device in their vehicles was activated, and it was assumed that this might affect their answers about future intention. Therefore no question of future intention was included in the questionnaire and rather than testing the original form of the theory of planned behaviour the theory was used as a frame of reference.

2.3. Analyses

Preliminary analyses of the data revealed that several measurements were not normally distributed and therefore non-parametric tests were used. Data from different time periods were compared using Wilcoxon Signed Rank Test and to examine the stability over time, for the latent variables in the theory of planned behaviour, Spearman’s Rank Order Correlation was used.

3. Results

Fig. 1 shows that the median test drivers’ mean time spent driving above the speed limit greatly decreased when the warning system was activated. It also shows that this initial decrease was reduced with time.

On streets with a 50 km/h speed limit the median test driver drove above the speed limit 24.9% of the total time driven before the warning system was activated. After activation the amount of time spent above the speed limit decreased to 8.5%. The amount of time spent above the speed limit then started to increase again and during the spring of 2003 the median test driver drove above the speed limit 19.3% of the total time driven. Even if the amount of time spent above the speed limit increased after long-term use the decrease was still significant during the spring of 2003, compared with the period before the warning system was activated \( Z(60) = -3.37; p < .01 \).

Furthermore, there was some variation of speed change within the group. Looking at speed changes greater than 5% it was shown that after activation 83.6% of the test drivers had decreased the amount of time they spent above the speed limit while 1.6% had increased the amount of time they spent above the speed limit. The remaining 14.8% of the test drivers had not made any major speed changes. In 2003, 44.3% of the test
drivers spent less time above the speed limit compared with the period before the warning system was activated while 16.4% of the test drivers spent more time above the speed limit. The remaining 39.3% of the test drivers spent approximately the same amount of time above the speed limit in 2003 as they did before the warning system was activated.

On roads with a 70 km/h speed limit the median test driver drove above the speed limit 12.2% of the total time driven before the warning system was activated. After activation the amount of time spent above the speed limit decreased to 4.3%. The amount of time spent above the speed limit then started to increase again and during the spring of 2003 the median test driver drove above the speed limit 10.7% of the total time driven. The decrease in the amount of time spent above the speed limit was still significant during the spring of 2001, compared with the period before the warning system was activated \( Z(60) = -4.23; p < .001 \), but during the spring of 2003 there were no longer any significant differences.

Furthermore, there was some variation of speed change within the group. Looking at speed changes greater than 5% it was shown that after activation 59.0% of the test drivers had decreased the amount of time they spent above the speed limit while 3.3% had increased the amount of time they spent above the speed limit. The remaining 37.7% of the test drivers had not made any major speed changes. In 2003, 37.7% of the test drivers spent less time above the speed limit compared with the period before the warning system was activated while 27.9% of the test drivers spent more time above the speed limit. The remaining 34.4% of the test drivers spent approximately the same amount of time above the speed limit in 2003 as they did before the warning system was activated.

On roads with a 90 km/h speed limit the median test driver drove above the speed limit 14.9% of the total time driven before the warning system was activated. After activation the amount of time spent above the speed limit decreased to 2.8%. The amount of time spent above the speed limit then started to increase again and during the spring of 2003 the median test driver drove above the speed limit 7.1% of the total time driven. Even if the amount of time spent above the speed limit increased after long-term use the decrease was still
significant during the spring of 2003, compared with the period before the warning system was activated \[ Z(60) = -2.58; p < .05 \].

Furthermore, there was some variation of speed change within the group. Looking at speed changes greater than 5% it was shown that after activation 49.2% of the test drivers had decreased the amount of time they spent above the speed limit while 4.9% had increased the amount of time they spent above the speed limit. The remaining 45.9% of the test drivers had not made any major speed changes. In 2003, 37.7% of the test drivers spent less time above the speed limit compared with the period before the warning system was activated while 18.0% of the test drivers spent more time above the speed limit. The remaining 44.3% of the test drivers spent approximately the same amount of time above the speed limit in 2003 as they did before the warning system was activated.

On streets with a 50 km/h speed limit the median test driver’s mean speed was 37.6 km/h before the warning system was activated. After activation the median test driver’s mean speed decreased to 36.7 km/h. The speed then started to increase again and during the spring of 2003 the median test driver’s mean speed was 37.8 km/h. The decrease in mean speed was significant during the period just after the warning system was activated \[ Z(60) = -3.76; p < .001 \], but during the spring of 2001 there were no longer any significant differences compared with the period before the warning system was activated. Visual inspection of Fig. 2 revealed that the speed distribution became somewhat more homogeneous, with both the low and the high extreme mean speeds disappearing, when the system was activated. Over time the speed distribution did, however, become more heterogeneous again.

On roads with a 70 km/h speed limit the median test driver’s mean speed was 57.0 km/h before the warning system was activated. After activation the median test driver’s mean speed decreased to 56.2 km/h. The speed then started to increase again and during the spring of 2003 the median test driver’s mean speed was 57.8 km/h. The decrease in mean speed was still significant during the spring of 2001, compared with the period before the warning system was activated \[ Z(60) = -2.60; p < .01 \], but during the spring of 2003 there were no longer any significant differences. The fastest driver’s mean speed decreased with approximately 6 km/h when the warning system was activated but, as a whole, visual inspection did not reveal any large changes in speed distribution.

On roads with a 90 km/h speed limit the median test driver’s mean speed was 82.2 km/h before the warning system was activated. After activation the median test driver’s mean speed decreased to 81.4 km/h. The speed then started to increase again and in 2003 the median test driver’s mean speed was 81.7 km/h. The decrease in mean speed was significant during the period just after the warning system was activated \[ Z(60) = -2.14; p < .05 \] and during the spring of 2003 \[ Z(60) = -2.51; p < .05 \], but during the spring of 2001 there were no significant differences compared with the period before the warning system was activated. Visual inspection did not reveal any large changes in speed distribution.

Spearman’s Rank Order Correlation showed that the 27 test drivers’ attitude, subjective norm and self-reported speeding correlated over time. There were significant correlations between the period before the
warning system was activated and the periods after activation in 2001 (A: \( r = .60, p < .01; \) SN: \( r = .58, p < .01; \) S-R S: \( r = .76, p < .001 \)) and 2004 (A: \( r = .61, p < .01; \) SN: \( r = .56, p < .01; \) S-R S: \( r = .58, p < .01 \)), respectively. In addition to this, there were significant correlations between the two periods after activation (A: \( r = .79, p < .001; \) SN: \( r = .76, p < .001; \) S-R S: \( r = .65, p < .001 \)). For perceived behavioural control there was no significant correlation between the period before the warning system was activated and the period after activation in 2001 (\( r = .11, \text{n.s.} \)) and 2004 (\( r = .15, \text{n.s.} \)), respectively. After activation, there was however a significant correlation between the periods in 2001 and 2004 (\( r = .71, p < .001 \)).

Table 1 shows how the test drivers rated their attitude, subjective norm, perceived behavioural control and self-reported speeding during different time periods. No significant differences were found between the period before the warning system was activated and the periods after activation in 2001 and 2004, respectively. Between the periods after activation there was, however, a significant difference in how the test drivers’ rated their attitude as well as their perceived behavioural control. In 2004, compared with 2001, the test drivers found it less acceptable (rated on a 5-point scale from 1 = not acceptable to 5 = totally acceptable) to exceed the speed limits [2001: median = 2.00, range = 2.25; 2004: median = 1.50, range = 2.25; \( Z(26) = 3.27, p < .01 \)], and easier (rated on a 5-point scale from 1 = very hard to 5 = very easy) to comply with these limits [2001: median = 3.25, range = 2.75; 2004: median = 4.00, range = 2.50; \( Z(26) = 3.17, p < .01 \)].

4. Discussion

The results show that initially the ISA speed-warning device greatly reduces the amount of time the majority of test drivers spend above the speed limit but that this effect decreases with time. Svedung (2005) showed that the time drivers in general spent above the speed limits on governmental roads in urban and rural areas in Sweden increased with approximately 4% between 2000 and 2003. Svedung (2005) did, however, also show that there was no decrease in time spent above the speed limits among the drivers in general, corresponding to the decrease the group of test drivers showed after the warning system on the ISA speed-warning device was activated. With regards to the amount of time drivers in general spent above the speed limits on non-governmental roads in urban areas, there were no significant differences between 2000 and 2003. As the changes in the amount of time spent above the speed limits differ between the group of test drivers and drivers in general, it is reasonable to believe that the large reduction in the amount of time spent above the speed limit, found among the test drivers, is indeed due to the ISA speed-warning device. The fact that the effect of the device decreased with time can to some extent be explained by the fact that the time drivers in general spent above the speed limits on governmental roads in urban and rural areas in Sweden also increased during the field trials with the ISA speed-warning device. The increase for drivers in general was, however, smaller (approximately 4%) than the increase for the group of test drivers (50 km/h: 10.8%, 70 km/h: 6.4%, 90 km/h: 4.3%) so it can not be the only reason for the decreased effect of the ISA speed-warning device. Also, a decreased effect of the ISA speed-warning device is in accordance with previous research, which has shown that the initial effect of an active accelerator pedal (which exerts a counterforce at speeds over the speed limit) is greater than the effect after 5–11 months (Hjälmndahl et al., 2002; Várhelyi et al., 2004).

In addition to the effect on the amount of time the test drivers spend above the speed limit, an effect on the test drivers’ mean speeds is also found. Initially, the ISA speed-warning device reduces the median test drivers’ mean speed for all three speed limits. The effect on the test drivers’ mean speeds is, however, smaller and less stable over time than the effect on the amount of time they spend above the speed limit. This is also in accordance with previous research (Regan et al., 2005) and may be due to the fact that the ISA speed-warning
device only affects the drivers when they exceed the speed limits and most of the mean speed data is therefore not affected by the warning system.

On streets with a 50 km/h speed limit the mean speed distribution becomes somewhat more homogeneous, with both the low and the high extreme mean speeds disappearing when the warning system is activated. This decrease in variation does, however, also decrease with time. On roads with a 70 km/h speed limit the fastest driver’s mean speed decrease with approximately 6 km/h when the warning system is activated but as a whole there is no large changes in speed distribution and neither is there on roads with a 90 km/h speed limit. These results differ from previous research where clearer decreases in speed variation have been found (Almqvist & Nygård, 1997; Brookhuis & De Waard, 1999; Duyunstee et al., 2001; Hjalmdahl et al., 2002; Regan et al., 2005; Várhelyi et al., 2004, 2005; Várhelyi & Mäkinen, 2001). More research is therefore needed. At the same time it should be remembered that the sample size in the current study is fairly small (N = 61).

One explanation for the decreased effect of the ISA speed-warning device with time may be found within classical conditioning where the concept of habituation has been acknowledged for many years. According to classical conditioning habituation is a decline in the tendency to respond to stimuli that have become familiar due to repeated exposure. The adaptive benefits with habituation are to allow us to ignore the familiar and to focus on things that are new and may signal danger. In the current study the flashing red light and sound signals were meant as warning signals, but in reality nothing much happened (except for the flashing red light and sound signals continuing) if the test drivers did not respond to the signals by decreasing their speeds. Therefore, with time, the test drivers are likely to have been habituated to the signals, making it easier to ignore them and to continue driving without decreasing their speeds.

Another reason for the test drivers’ tendency to ignore the warning signals can be that some technical problems occurred during the study. Even though the digital map was thoroughly tested in the field before it was distributed to the test drivers, it still contained several errors regarding speed limits. As the test drivers experienced some of these errors they might have actively learnt to ignore the warning signals. Besides making future ISA-systems as reliable as possible, drivers’ tendency to ignore the warning signals from the ISA speed-warning device must be counteracted. This can, for example, be done by increasing the drivers’ motivation to adapt their driving behaviour according to the information given by the device or by changing the design of the device.

To increase the drivers’ motivation to adapt their driving behaviour according to the information given, economic incentives can be used. Ninety-five test drivers in Borlänge participated during the spring of 2002 in a project aimed to study the effect of economic incentives (Hultkrantz & Lindberg, 2003). Half of the test drivers received a bonus of 200 SEK (≈20 EUR) while the other half received a bonus of 500 SEK (≈50 EUR). Their speeding behaviours were then registered and for every minute they spent speeding a certain amount, ranging from 0 to 2 SEK (≈0.2 EUR), were taken from their bonuses. The results showed that even these relatively small incentives resulted in reduced amount of time spent speeding. In the future it may be possible to combine the use of an ISA-system with a reduction of, for example, the car insurance premium.

When looking at the effect of the ISA speed-warning device it is important to remember that the device tested is a first generation voluntary system. Another type of system that has previously been tested is an intervening system where the vehicles’ speed is limited to the current speed limit, and not overrideable by the drivers (Comte, 2000; Pääätalo, Peltola, & Kallio, 2001; Persson, Towliat, Almqvist, Risser, & Magdeburg, 1993; Van Loon & Duyunstee, n.d.; Várhelyi & Mäkinen, 2001). These systems have proved to be very effective in keeping the speeds down, but the acceptance of the systems is lower than for other types of ISA-systems (Pääätalo et al., 2001). Previous studies have also shown that different types of drivers differ in their acceptance of the systems as well as to which degree they are affected (Hjalmdahl, 2004). A possible solution for how to improve the long-term effect of an ISA-system may therefore be to combine different systems depending on where the vehicle is (e.g. urban or rural areas) and who is driving (e.g. experienced or inexperienced drivers).

The current study also shows that test drivers’ attitude, subjective norm and self-reported speeding correlate over time while there are no significant correlations between the test drivers’ perceived behavioural control during the period before activation and the periods after. This suggests that the activation of the warning system affects the test drivers’ attitude, subjective norm and self-reported speeding in a more homogenous way than their perceived behavioural control. Long-term use, on the other hand, affects the test drivers in a homogenous way with regards to attitude, subjective norm, self-reported speeding, as well as perceived behavioural control.
Finally, the results show that the test drivers find it less acceptable to exceed the speed limits and find it easier to comply with them in 2004 than in 2001. At the same time there are no significant differences in the test drivers’ self-reported speeding between 2004 and 2001. The fact that the test drivers find it less acceptable to exceed the speed limits, at the same time as they report no changes in their speeding is hard to explain. It is, however, important to be careful while considering these results as the sample size for the questionnaires is very small (N = 27). A possible explanation for why the test drivers find it easier to comply with the speed limits in 2004, compared with in 2001, may be that it took a while for them to get used to the new technical device before they felt comfortable using it to facilitate their speed choice. As the test drivers rate their perceived behavioural control fairly highly (MD = 4.0; rated on a 5-point scale from 1 = very hard to 5 = very easy) in the end of the trials it suggests that they regard the ISA speed-warning device as a useful tool to help them comply with the speed limits. This is in line with a previous study, which used the acceptance-scale proposed by Van der Laan, Heino, and De Waard (1997) as a frame of reference. In this study two different factors, named usefulness and satisfying, were extracted. The items included in the usefulness factor did, in general, score higher (were more positively perceived) than the items included in the satisfying factor. This suggests that the drivers were positive towards the idea of the informative ISA speed-warning device and could see its usefulness at the same time as they were not totally satisfied with the experience of the ISA speed-warning device (Wallén Warner, 2005).

To sum up, initially the ISA speed-warning device greatly reduces the amount of time the majority of test drivers spend above the speed limit, and to some extent also reduces their mean speeds, but this effect decreases with time. The results also show that the activation of the warning system affects different drivers in quite a homogenous way, with regards to attitude, subjective norm and self-reported behaviour, but not with regards to perceived behavioural control. After activation, long-term use does, however, affect the test drivers in a homogenous way with regards to attitude, subjective norm and self-reported behaviour, as well as perceived behavioural control. When considering these results it is important to remember that the device tested was a first generation ISA speed-warning device without any consideration taken regarding the rapid development of, for example, the interface between driver and device that has taken place during recent years. To say that more research is needed is very common, but in this case we feel that it is fully justified to say that we need to find out more about, for example, how we can motivate the drivers to adapt their driving behaviour according to the information given and what the optimal design of the device is. If we do not do this we are risking investing large sums of money in nation-wide implementation of different ISA-systems whose long-term effects are questionable.

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References


