

# THE EFFECT OF ISA IN RELATION TO SPEED LIMIT CREDIBILITY

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**ABSTRACT:** One of the most challenging areas for ITS to contribute to road safety is controlling speed behaviour. Speeding is still common practise on many roads and contributes to a significant number of crashes. An Intelligent Speed Assistance (ISA) aims to reduce speeding in a more or less intrusive manner. This is promising, however the acceptance of ISA systems is still very low. Another promising approach to reduce speeding is by improving the credibility of speed limits. A driving simulator study is conducted to investigate the effect of credibility, with or without using an open informative and warning ISA. The results show that both ISA and credibility of speed limits are effective measures to reduce speeding. Non-ISA users appear to be more sensitive for the credibility of speed limits than ISA users. With regard to the acceptance of the ISA system used in this study, the expectations were fairly positive than the experiences.

## 1 Introduction

### 1.1 Background

The faster one drives, the more likely a crash, and, in case of a crash, the more severe the injury consequences [1,2]. Excessive speed is a very common phenomenon in Europe and many non-European countries. Typically, at any time 50% of drivers are exceeding the speed limit [3] and a large safety benefit could be obtained if driving speeds were reduced. There are a number traditional and well proven measures to reduce driving speeds and to make drivers comply better with the speed limit, in particular infrastructure measures and speed enforcement. An effect is also assumed from credible speed limits, i.e. speed limits that meet the expectations of the road users, given the road features and the road surroundings. Credibility will not only have an effect in itself, but may also enhance the effects and the acceptance of other types of measures [3, 4]

A newer, and very promising measure to reduce speeds and the number of speed-related crashes is Intelligent Speed Assistance (ISA). It has been calculated, based on the known relationship between speed and crash involvement/severity, that ISA will have a substantial effect on road safety, in particular the more intervening systems that make speeding physically impossible and that are based on dynamic speed limits [5].

While such advanced systems may be technically possible, their widespread use will need more time. Less advanced systems, based on fixed speed limits, have been tested in various countries, both in small and large field trials,

generally with positive effects on average speed [e.g. 6, 7, 8, 9]. Less intervening systems, those only informing the driver about the (fixed) speed limit in force are already on the market, e.g. Speedalert.

One of the important issues that hinder the widespread implementation of ISA is related to the public acceptance of systems. While more than half of the European drivers state that they are in favour of a system that prevents them from exceeding the speed limit [10], drivers participating in field trials had less positive ideas about ISA. However, after they had experienced the system, their opinion turned out to be more positive [6, 9].

## **1.2 Aim and research questions**

This study aimed to investigate whether credibility affects speed choice when driving with an ISA system that informs the driver about the speed limit in force and warns if the speed limit is exceeded. As public acceptance is of major importance, the acceptance of the used ISA system was also investigated. This lead into the following research questions:

1. What is the effect of speed limit credibility on speed choice for ISA users in comparison to non-ISA users?
2. What is the difference in acceptance of the ISA system before and after the (test drive) experience?

## **2 Method**

### **2.1 Design of the study**

The research questions were investigated in a driving simulator study. A total of 41 subjects drove along a simulated network of mainly rural roads with speed limits of 60, 80 or 100 km/h. The study focused on speed choice at 7 road sections with a speed limit of 80 km/h, the other road sections were added to create a realistic environment.

### **2.2 Independent variables**

In the experiment two variables were manipulated, the use of ISA and the credibility of the speed limit. The use of ISA was varied between subjects, half of the subjects were supported by an ISA system, and the other half were not. The ISA system used in this experiment was integrated in a navigation device. The ISA system provided continuous visual information about the speed limit in force and when the driver exceeded the speed limit the ISA system warned the driver visually (the speed limit indicator on the navigation device increased in size and flickered) and verbally (a female voice said: "You're exceeding the speed limit. The speed limit is .. km/h." This message was repeated every ten seconds until the speed was reduced to below the speed limit). Exceeding the speed limit was defined as 1 km/h or more over the posted limit.

The credibility of the speed limit was manipulated by varying a number of road characteristics that were identified in literature as being relevant for speed choice [e.g. 11, 12, 13], and that were possible to simulate in a driving

simulator. Road bendiness for example is considered as relevant for speed choice, but hard to simulate in a driving simulator because it increases the chance of simulator sickness. The road characteristics that were used to manipulate the credibility were road width, presence of vegetation near the road, and the type of separation between the driving directions. Each road characteristic was expected to have an effect on the intuitive speed, like a small road was assumed to reduce speed while a wide road was assumed to increase speed. Each road section had a different combination of characteristics. At some road sections all of the manipulated road characteristics were assumed to increase the intuitive speed, on the other road sections a mixture of characteristics that were assumed to increase speed and those that were assumed to decrease speed. Based on this the road sections were categorised as having a more or less credible speed limit. As literature on the subject was quite limited, the credibility of the speed limit was validated within the experiment. All subjects first drove the test route without showing any speed limit. The results showed that at the 80 km/h roads the subjects intuitively drove about 80 km/h at the road sections with credible speed limits, and that they exceeded the speed limit by more than 5% at the road sections with less credible speed limits.

## **2.3 *Dependent variables***

### **2.3.1 *Driving speed***

The main dependent variable was driving speed. To measure driving speed two variables were measured: average driving speed and speeding time. The average driving speed was computed for each road section. To avoid an effect of acceleration and deceleration near intersections, the computed averages are based on the part of the road section from 100 m after an intersection until 150 m before the next intersection. Speeding time was defined as the percentage of time on a road section that the limit was exceeded by 10% or more, thus 88 km/h or more at 80 km/h roads.

### **2.3.2 *Acceptance of the ISA system***

The ISA users were informed about the ISA system before the test drive. They received a paper with information on the system and the type of information it would provide. Based on this information the subjects were asked about their expectations of the system. After the test drive, they were asked about their satisfaction with the ISA system based on their actual experience. The expectations and experiences were measured by presenting statements and a five-point answering scale (completely disagree, disagree, neutral, agree, completely agree). The same set of statements was used for the expectations and for the experiences, the only difference was the tense, the first set was in the present tense while the second set was in the past tense. (E.g. "It seems pleasant to me that...." versus "I found it pleasant that ....").

## **2.4 *Analysis***

The effects of ISA and the credibility of speed limits were determined by means of an analysis of variance with repeated measurements. Within these analyses the use of ISA was considered as a 'between subject factor'. The repeated

measurement concerned the speed behaviour on the different road sections with different speed limit credibility. For all analyses, a critical significance level of 5% was applied.

### 3 Results

The results for average driving speed and speeding time are shown in respectively Figure 1 and Figure 2. In the figures the values are shown for ISA users and non-ISA users at road sections with low and high credibility of the limits.

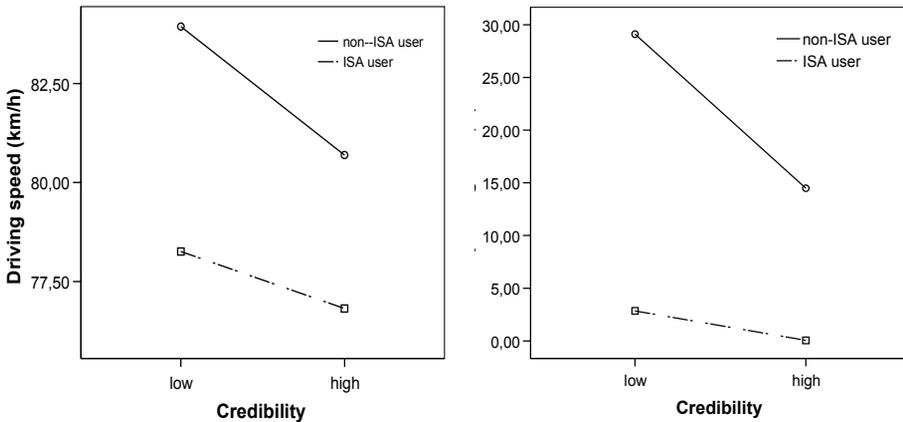


Fig.1. Average driving speed Fig.2. Speeding time

#### 3.1 The effect of ISA

The main effect of ISA on driving speed was significant ( $F_{1,39}=11.33$ ;  $p<0.01$ ). ISA users drove significantly slower than non ISA users. Moreover, ISA users on average had a driving speed below the speed limit (77.5 km/h), whereas non-ISA users had an average driving speed above the speed limit (82.3 km/h).

The main effect of ISA on speeding time was also significant ( $F_{1,39}=10.76$ ;  $p<0.01$ ). ISA users exceeded the speed limit significantly less than non ISA users. ISA users, on average, did not exceed the speed limit at road sections with credible speed limits and hardly exceeded the speed limit at road sections with less credible speed limits.

#### 3.2 The effect of credibility

The main effect of speed limit credibility on average driving speed was significant ( $F_{1,39}=19.61$ ;  $p<0.001$ ). The subjects drove significantly slower at road sections with credible speed limits than at road sections with less credible speed limits. This is the effect for the complete sample, half of the subjects with and half without ISA. As the current practise is that hardly anyone uses an ISA system, it is also interesting to look at the effect for non-ISA users only. A simple main effects analysis showed that for non-ISA users the effect of

credibility was significant ( $F_{1,39}=18.38$ ;  $p<0.001$ ). Average driving speed was lower at sections with credible limits than at sections with less credible sections. For the ISA users the effect of credibility was not significant, but there is a trend ( $F_{1,39}=3.79$ ;  $p<0.1$ ) that also ISA users drive slower at sections with credible limits.

The main effect of the credibility of speed limits on speeding time was also significant ( $F_{1,39}=12.41$ ;  $p<0.005$ ). The subjects exceeded the speed limit significantly less at road sections with credible speed limits than at road sections with less credible speed limits. Again, when looking separately at the ISA and the non-ISA users, the effect of credibility was significant for the non-user group ( $F_{1,39}=17.08$ ;  $p<0.001$ ), but there was only a trend for the ISA users ( $F_{1,39}=0.66$ ;  $p<0.5$ ).

### **3.3 *The interaction between ISA and credibility***

The interaction effect between ISA and credibility on average driving speed was not significant, but there is a trend ( $F_{1,39}=2.92$ ;  $p<0.1$ ) that non-ISA users were more sensitive for the credibility of speed limits than ISA users. This trend is supported by the simple main effects reported in the previous section that indicate that the effect of credibility is significant for non-ISA users and not for ISA users.

The interaction effect between ISA and credibility on speeding time was significant ( $F_{1,39}=5.72$ ;  $p<0.05$ ). Non-ISA users were more sensitive for the credibility of speed limits than ISA users.

### **3.4 *Acceptance of the ISA system***

The responses to the statements on the expectations of and experiences with the ISA system are presented in Figure 3. The results show that expectations of the subjects were somewhat positive and their satisfaction slightly decreased to neutral after the test. In particular the voice that warned when exceeding the speed was not appreciated. The experience did not change much of their opinion on the visual information and the visual warning, they were well accepted.

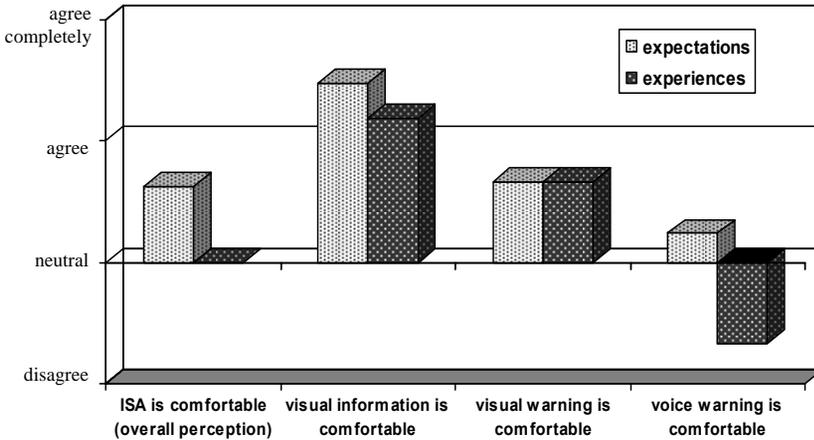


Fig.3. Expectations of and experience with the ISA system

## 4 Conclusions and discussion

### 4.1 Effect of ISA

The study found a significant effect of ISA on the average driving speed and on speeding time. The ISA system in the study that both informed and warned when the speed limit was exceeded resulted in lower speeds and less time driving above the speed limit. These results confirm the findings of the large majority of studies that investigated the effect of ISA [ e.g.6, 9, 14, 15,16].

### 4.2 The effect of credibility

The results indicated that, overall, credible speed limits result in lower speeds and less time exceeding the speed limit than speed limits that are less credible, because they are considered to be too low. Systematic research on the effects of credible speed limits is still lacking, but these results confirm the assumptions made by many experts [e.g. 3, 4, 17, 18].

### 4.3 The effect of ISA related to speed limit credibility

The first main research question was whether the effect of credible speed limits was similar for ISA and non-ISA users. When looking at the time drivers speeded, this appeared not to be the case. The effect of speed limit credibility was stronger for non-ISA users than for ISA users. Looking at average speed, however, there was no significant difference between ISA users and non-ISA users, although the trend pointed in the same direction. Looking separately at the effects of credibility for ISA and non-ISA users, it appeared that this had an effect without ISA, but not with ISA drivers, both for average speed and for speeding. So, the results of this study suggest that, when driving with an informing and warning type of ISA, the credibility of speed limits does not affect

the amount of time people drive in excess of the speed limit. Regarding average speed, the results are less clear, but point in the same direction.

When interpreting this outcome, it must be born in mind that the ISA used in this study was an open one. Drivers could make their own choice about their driving speed. However, within the open category, it was a fairly intrusive system. Warnings started when the speed limit was exceeded by just 1 km/h and were repeated every 10 seconds, not only visual but also verbally. It would be well possible that speed limit credibility would affect driving speed of ISA drivers more, when the system was only informing or when the warnings were less frequent and less intrusive.

#### **4.4 Acceptance of the ISA system**

The second main research question was related to the acceptance of the ISA-system by the drivers. The results showed that the subjects had fairly positive expectations. However, they were somewhat disappointed after they had actually experienced it. In particular, the overall convenience of this type of ISA and of the verbal warning was judged less positive. The verbal warning was even judge negatively.

This finding is in line with another study with an informative ISA system that also concludes that there is no difference in acceptance before and after a test ride. However, most studies report that drivers become more enthusiastic about ISA, once they have experienced it in practice [6, 9, 19, 20].

One explanation of our finding may be that this particular ISA system was quite strict, with visual and verbal warnings at 1 km/h or more over the limit and repeated every 10 seconds. This could particularly explain why the drivers disliked the verbal warning system. Acceptance of the system may increase if the threshold for warnings would be higher and the warning frequency lower. Other studies also found that the less intervening systems are accepted better [5]. At the same time it is expected that, in that case, the effect of the ISA system would be smaller. Clearly, it is a matter of finding a balance between acceptance and effectiveness of the system.

Another explanation of the contradictory findings in our study may lie in the fact that our study focused on rural roads and more particularly on 80 km/h roads. It is well possible that the acceptance of ISA is different for urban roads (with 30 and 50 km/h speed limits) than for rural roads.

Our study did not make a distinction between the acceptance of ISA at road sections with a credible speed limit and sections where the speed limit was considered to be too low. Hence, based on the current study, we cannot say whether credible speed limits improve acceptance.

#### **4.5 Overall conclusion**

Based on the results of this study we can conclude that ISA is a promising instrument to reduce speeding and increase road safety. In line with previous research, the results of this study indicate that an (open) ISA system on its own has the potential to reduce average driving speed to below the speed limit and to decrease speeding.

Credibility of speed limits is also an important factor in speed choice and can substantially contribute to achieving lower speeds and less speeding. Still, credible speed limits cannot achieve the same result as the informative and warning ISA system of the current study.

Speed limit credibility seems to have hardly an effect if speed choice is supported by a rather strict informative and warning ISA system. It is expected, however, that speed limit credibility will be more important in case of less intruding systems that can be more easily ignored. In addition, it is likely that credible speed limits will increase acceptance of ISA systems. Future research would need to find out.

It is important to be aware of the fact that speeding behaviour is related to many different factors that are hard to realize in a driving simulator study, like time pressure, whether the driver expects to be punished for speeding, risk estimation and so on. In this study the some influencing factors, ISA and credibility, were studied. For future research it would be interesting to do a similar study on the real road in order to validate if the results are the same and it would be interesting to look and the interaction of the effects investigated in this study and other factors that effect speeding behaviour.

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