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Controlled study of ISA effects: comparing speed attitudes between young volunteers and external controls, and the effect of different ISA treatments on the speeding of volunteers

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Abstract: This study is a part of an ongoing ISA project in Denmark. Its aim was to clarify two human factors issues, (1) the difference in attitude between ISA-volunteers and non-volunteers, and (2) the relative impact on speeding of two factors, ISA-information and driver motivation. The first part of the study compared survey data from ISA-volunteers with those of non-volunteers. The two groups differed in their judgement of ISA features and anticipated effects of driving with ISA, whereas no differences were found in judgement of speed limits, attitude to speeding or reported driving style. The second part of the study was a driving experiment in which two factors, informative ISA and an economic incentive for not speeding, were manipulated between groups of volunteers. A control group had ISA switched off and received insurance discount independent of their speeding. This group did not reduce their speeding in the experiment period, whereas another group, also with ISA switched off but with insurance discount dependent on their speeding reduced their speeding by a small amount. Two groups, both driving with ISA switched on showed a substantial reduction in their speeding. The effect of informative ISA alone was substantial, which presumably prevented a further gain from combining ISA information with the incentive.

1 Introduction

Intelligent speed adaptation (ISA) is an advanced driver assistance system with a great safety potential. ISA addresses a core variable of safe driving and driving speed, and it leaves higher-order task control, manoeuvring and navigation, to the driver [1]. ISA equipments can be informative, interactive or intervening. Interactive and intervening equipments are associated with an active gaspedal, whereas

informative ISA refers to equipments based on a combination of visual and auditory messages. Compared with conventional speed signposts, informative ISA has two advantages: ISA displays the current speed limit continuously and ISA prompts the driver, if the speed limit is exceeded. Thus, informative ISA can prevent the driver from unintended speeding, and with no exception long-term field studies of ISA have reported a positive effect of ISA on speeding (see [2–4] for recent reviews of

previous ISA field studies), and negative effects of ISA on general driving behaviour have not been found [5, 6]. ISA has been found to reduce mean speed, speed variance and the time driven at a higher speed than the speed limit. However, recently, Warner [4] found that the speed reduction, observed in an early phase of a long-term ISA project, tended to decrease in the late phase of the project. Moreover, tendencies to override intervening ISA, if possible, have also been reported [7]. These findings indicate that, although all ISA users have been volunteers, encouraged by ISA to comply with the speed limit, they sometimes commit speed violations. The findings also suggest that the beneficial effect of informative ISA on speeding is highly dependent on driver motivation. Thus, human factor issues beyond interface design may be important to a reliable evaluation of the speed-reducing effects of ISA. In fact, the use of volunteers is an inherent problem in ISA studies. Volunteers are biased by selection, and most likely, their attitude to safe driving, driving speed and driving with ISA make them more compliant with informative ISA than the average driver would be if ISA was a common device. Moreover, the majority of ISA volunteers has been mature and experienced drivers and most often with more car options than the ISA-equipped vehicle. The aim of the present study was to clarify two human factor issues of importance to a reliable assessment of ISA: the possible difference – in particular in the attitude to speeding – between volunteers and non-volunteers and the relative impact of the two factors, informative ISA equipment and an incentive for not speeding, on the volunteers' compliance with the speed limit.

1.1 Pay as you speed project

The study was a part of the Pay as You Speed (PAYS) ISA project. The project was a follow-up of the previous INFATI project [8, 9]. It differed from previous ISA projects in several respects: it addressed young car owners exclusively; it combined ISA with an incentive for compliance with the system [10]; it used an extended road network with GPS-based ISA surveillance; it required volunteer commitment for 3 full years and the first 6 months of the project period were devoted to an experiment, in which the two factors, informative ISA and incentive for not speeding, were manipulated independently. More specifically, the ISA PAYS project was concerned with the effect of ISA on the speeding of car owners aged between 18 and 28, in a road network of ~22 000 km with ISA coverage of all the speed limits. The incentive offered for volunteering was basically a 30% discount on the car insurance, but in case of speeding, the discount would be reduced in accordance with a penalty point system [11]. The focus on recruitment of young drivers was motivated

by the fact that young drivers are known to be speeding, to lack driving experience and to have a high accident risk. The need for ISA in this group is objectively high. As it turned out, the recruitment of young drivers as volunteers is not easy.

2 Method

The study contained two parts: a survey including the ISA volunteers and a group of non-volunteers from the same population of young car owners and an experiment including only the ISA volunteers.

2.1 Recruitment of volunteers for the driving experiment

The recruitment of young volunteers started in September 2005. The aim was to include 300 young car owners in the driving experiment. All car owners, a total of 11 400 subjects, in the County of North Jutland aged between 18 and 28 were invited to volunteer. They received a letter from the project, in which they were exhorted to sign up the project via the PAYS homepage. After signing up, they would be contacted by a project official for further appointments on their participation. The PAYS website contained information about the conditions for participation, such as a binding period of 3 years, a 30% insurance discount and the necessity to have their car insured in a specific insurance company. The website also included a description of the penalty point system, for example, how the insurance discount would be reduced in case of speeding (see [11, 12] for detailed description of the penalty point system). By April, 2006, a total of 220 recipients had signed up on the website; however, by September 2006, most of them had dropped out again leaving only 50 young drivers to start as volunteers in the PAYS experiment.

2.2 Recruitment of non-volunteers for the PAYS Survey

Non-volunteers, were young car owners who had not responded to the invitation to participate in the PAYS project 6 months after being invited, were invited to fill in the PAYS questionnaire. The non-volunteers were selected by their day of birth. They were offered a chance to win a lottery with three gift vouchers worth 430 euros for filling in the questionnaire. Although a total of 1973 young car owners were invited, only 54 actually completed the questionnaire.

2.3 Survey

The ISA volunteers were required to fill in the questionnaire after having ISA installed in their car and before having the system switched on. The

questionnaire used in the PAYS project was not a new invention; it replicated questions from other surveys including questions used in the NHTSA National Survey of speeding and other unsafe actions [13], the SARTRE project [14], Scandinavian questionnaires used in previous ISA projects [15,16]. Apart from background factors such as age and driving experience, questions were related to driving style, attitudes to safe driving, driving speed and speed limits and to risky traffic behaviour. The respondents were also required to judge a number of frequently used ISA features and to anticipate effects of driving with ISA. The questionnaire was monitored via the PAYS website; it could be accessed by the ISA volunteers by their ID number; non-volunteers could use their car registration number as a password. Using the advantage of a web-based questionnaire, the respondents were provided with a continuous scale for indication of their attitudes. In subsequent analysis, the resolution of scale was set to 400 with scale values ranging from -200 to $+200$ in bipolar questions.

2.4 ISA equipment

A detailed description of the ISA equipment and the motivation for criteria values of the ISA system used in this project is found elsewhere [11,12] and is only summarised here. The equipment consisted of an on-board unit (OBU) which served the communication with external units. The user interface consisted of a display, which showed the current speed limit and a voice message which announced the current speed limit and 'You are driving too fast' in case a driver exceeded the legal speed limit. The criterion for activation of the voice message was a speed of 5 km/h over the legal limit (limit + 5) maintained for more than 6 s. The voice message would be repeated each sixth second, until the speed was below the limit + 5. By the activation of the third message, the count of 'penalty points' would start, which would affect the size of the driver's insurance discount.

2.5 Driving experiment, design and procedure

In order to observe the volunteers' unsupported speed, the display and the voice message was switched off during the first one and a half months after the instalment of the OBU (testperiod). In the next four and a half months (the ISA period), the volunteers were randomly assigned to one of the four predefined ISA treatments: The 'internal control group' continued to drive without ISA display and voice message, and this group would not have their discount reduced for speeding. The group was as an internal control group, since they had accepted to volunteer, but their speeding would be influenced neither by ISA information nor by a concern for the size of their

incentive. The 'incentive group' also continued to drive without ISA display and voice messages, but the size of their discount would depend on their speeding. Thus, this group had to use conventional road signs for their information, and only their motivation to obtain the insurance discount could prevent them from speeding. The 'information group' had both ISA display and voice messages, but just like the internal control group, their insurance discount was unaffected by their speed behaviour. Thus, this group would be encouraged not to speed by the voice message, but they would not be motivated by the size of the incentive to refrain from speeding. The 'combined group' was provided with ISA display and voice messages, and the size of their discount would depend on their speed behaviour. Thus, this group both had ISA information and was motivated not to speed by the size of the incentive. All the volunteers could access their actual speeding record on the web.

3 Results

As the PAYS project is still running, the present analyses are based on the first results. Owing to an unsuccessful recruitment of volunteers, data are limited to a few subjects. This both prohibits a detailed analysis and limits the generality of the actual findings.

3.1 Survey data

Survey data have been available only for 32 active volunteers; 8 of the original 50 volunteers served the final testing of the system, 6 did not complete the experiment and 4 volunteers did not respond to the questionnaire prior to having the ISA system switched on. Data were obtained from only 32 volunteers and 54 non-volunteers, less than 1% of the original population. The sample is probably not representative to the population of young drivers. However, we may speculate that the non-volunteers were well informed but resistant about the ISA PAYS project rather than uninformed and indifferent about it. The limited number of respondents implied a considerable within-group variance in all the background factors. Because of this variance, all the differences were tested with the non-parametric Man-Whitney U test, which showed that the between-group differences were not statistically significant (Table 1).

3.1.2 Self-reported driving style: The self-reported driving style of the volunteers and of the non-volunteers was quite similar. Both groups scored themselves on the positive side on a scale contrasting the following items: considerate–inconsiderate, patient–impatient, tolerant–intolerant, attentive–inattentive, calm–annoyed and safe–risky drivers. As can be seen in Fig. 1, the volunteers scored themselves somewhat higher on positive side than did

Table 1 Summary of background factors in the group of volunteers and the external control group

	Share of gender, percentage	Year of birth mean	Driver licence months	Car ownership, months	Mileage last year, km
volunteers					
males	71.9	1982	67.0	47.5	21 408
females	28.1	1982	70.0	36.6	13 055
controls					
males	70.4	1981	81.6	46.8	19 187
females	29.6	1981	83.7	51.0	10 337

the non-volunteers. Despite the fact that the difference for each individual item was small, and none of the differences was found statistically significant, the general tendency, more positive scores in six out of six items for the volunteer group, was actually statistically significant on a sign test ($P < 0.02$).

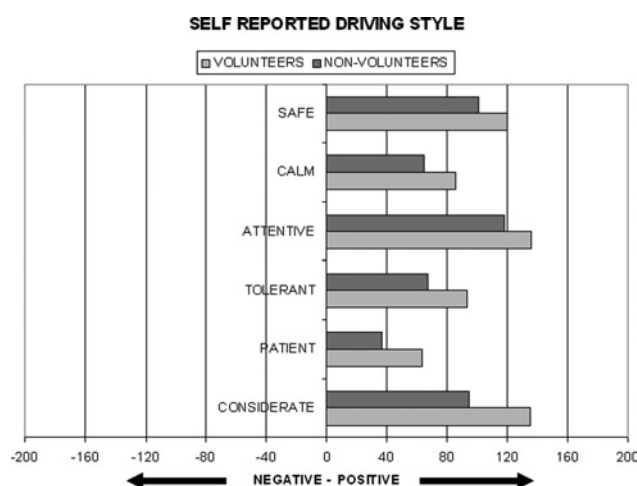
3.1.3 Attitude to speeding and speed limits: A number of different items in the questionnaire addressed the attitude to speed limits and speeding. The respondents were required to propose an appropriate legal speed limit for the standard road types: urban roads, rural roads and motorways of which the basic speed limit in Denmark is 50, 80 and

130 km/h, respectively. In line with previous findings [9], the majority of the respondents proposed the actual speed limit for urban roads and motorways, whereas the majority proposed a higher legal limit, ranging from 90 km/h to 110 km/h, for rural roads, and nobody proposed a lower limit than the current one, 80 km/h (Table 2).

The issue of speeding was further explored by asking the respondents to indicate their agreement with a number of speed statements used in the above-mentioned surveys. The statements generally concerned the personal motivation to speed (1, 2, 3, 4, 8, 9, 10) or general social norms about speeding (5, 6, 7).

The statements were the following:

1. 'I enjoy the feel of speed'
2. 'The faster I go the more attentive I am'
3. 'I often get impatient with slow drivers on the road'
4. 'I try to reach my destination as fast as I can'
5. 'It is more important to follow traffic than to comply with speed limits'
6. 'It is a duty of all drivers to comply with the speed limits'
7. 'Speed limits are virtually unnecessary in traffic'
8. 'If I am busy I may run a risk in traffic'

**Figure 1** Self-reported driving style on a contrast scale with zero as a neutral point**Table 2** Percentage of drivers proposing a lower, the current or a higher speed limit in the group of volunteers and the external control group

	Urban road <50>			Rural road <80>			Motorway <130>		
volunteers	3.1	84.4	12.5	0	21.9	78.1	12.5	65.6	21.8
controls	9.2	77.8	13.0	0	18.5	81.5	16.7	50.0	33.4

9. 'If I was sure that I would not get caught by the police, I would drive faster than I usually do'

10. 'I sometimes feel a pressure in traffic to drive faster than enjoy'

Again, the between-group differences in the judgements of individual items were not found significant, which may be due to the small sample size and a high within-subjects variance (Fig. 2).

3.1.4 Assessment of ISA features and of anticipated impact of ISA: ISA volunteers and external controls differed considerably in their assessment of common ISA features. The differences between the groups on individual items shown in Fig. 3 were tested with a one-way ANOVA, and all differences were found highly significant ($P < 0.001$) except two, the 'heavy' and the 'hard' gas pedal. Apparently, both the volunteers and the non-volunteers agreed in their negative evaluation of the features usually associated with interactive and intervening ISA equipment. Expectedly, the volunteers' assessment of the system used in the present project (PAYS-ISA) was more positive than that of the non-volunteers. However, it should be noticed that the mean score of the non-volunteers is neutral rather than negative. This finding suggests that it was not the design of the actual system that prohibited them from volunteering.

The judgements of the possible impacts of driving with ISA also differed between the two groups; not surprisingly, the scores of ISA volunteers were higher on positive effects, and lower on negative effects, whereas the reversed pattern was generally observed in the non-volunteers. The differences between the two groups for each item were tested with a one-way

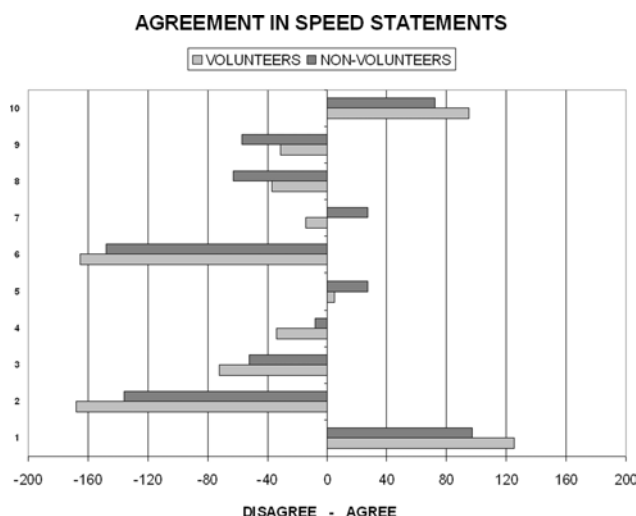


Figure 2 Indication by group of agreement (+200) or disagreement (-200) with the 10 speed statements

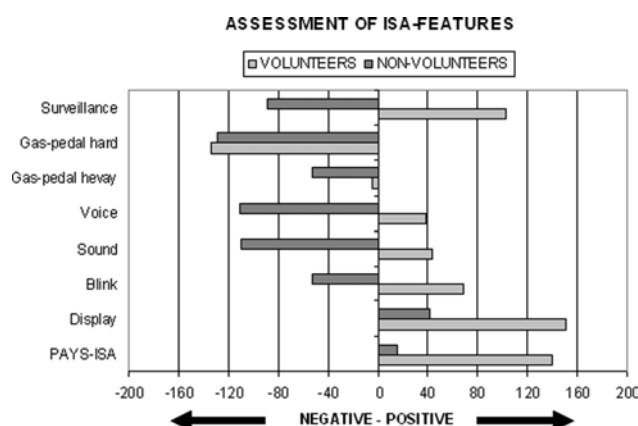


Figure 3 Positive (+200) and negative (-200) assessments of ISA features including a general assessment of a description of the ISA PAYS system

ANOVA and were found to be significant ($P < 0.008$), except that volunteers and non-volunteers were not different in thinking that driving with ISA could annoy other drivers (Fig. 4).

3.1.5 Discussion of questionnaire results: Volunteers and non-volunteers were similar in their background and in their stated driving style. They did not show differences in their attitude to speed limits nor to speeding. The judgements of ISA features and anticipated effects of driving with ISA differed between the two groups were generally highly significant, but the two groups were similar in their negative judgement of the active and hard gas pedal usually associated with interactive and intervening ISA equipments. They were also consistent in anticipating that driving with ISA could annoy other drivers. Not surprisingly, volunteers were more positive to ISA features than non-volunteers, and they anticipated more positive effects of driving with ISA than did the non-volunteers. According to the questionnaires, the great difference between the volunteers and non-volunteers

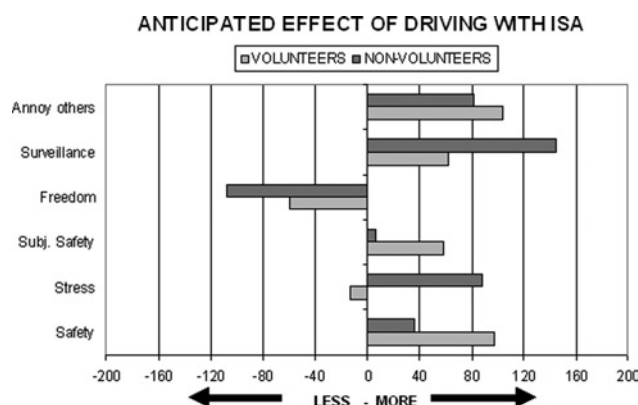


Figure 4 Assessment of anticipated increase (+200) or decrease (-200) in items associated with driving with informative ISA

lies in their attitude to ISA, whereas differences in their background, their speed attitudes and driving style were small and were not statistically significant.

3.2 Effect of ISA treatment on the volunteers' speeding

The effect of ISA on speeding was calculated across the speed limits from 40 to 130 km/h which included approximately a total of 180 000 km, driven. The number of kilometres driven below and above the activation level of the ISA system (limit + 5) was summarised by week, by subject and by speed limit in three periods of 6 weeks. The first period was the test period (TEST) in which all volunteers drove with ISA switched off and would not get notified for speeding; the second period (ISA1) was the first 6 weeks in which the volunteers were assigned to groups with different treatments and the third period (ISA2) was a continuation of the experiment without changes in the experimental set - up.

One volunteer had no data registered in a full 6 - week period and was excluded from the analysis. Of the remaining 31 volunteers, 8 were in the control group, 7 in the incentive group, 7 in the information group and 9 in the combination group. The effect of treatment was estimated by calculating the percentage of the total distance driven, which was driven at a higher speed than the activation level of the ISA system (limit + 5). To prevent the difference between subjects in the total amount of kilometres driven from affecting the effect size, the share of speeding was calculated for each subject individually prior to calculating the group average.

Fig. 5 shows that the share of kilometres driven with a speed over the activation level of the ISA system

(limit + 5) decreased for the two groups with ISA switched on. A two-way ANOVA supported this; the main effect of group was statistically significant ($F = 67.9$ $df = 3,3$ 450, $P < 0.000$) and so was the effect of period ($F = 44.6$ $df = 2,3$ 450, $P < 0.000$). There was significant interaction between these two factors ($F = 24.6$ $df = 6,3$ 450, $P < 0.000$); subsequent pairwise comparisons of the four groups revealed that the difference between the 'information' and the 'combination' groups was not statistically significant. A subsequent one-way ANOVA was used for comparing speeding over period (TEST, ISA1 and ISA2) within each group. The differences in speeding between the test period and the two ISA periods for the 'information' and for the 'combination' groups were confirmed (both $P = 0.0005$) with no difference between the first and the second experimental periods. The two groups that continued to drive without ISA switched on did not obtain the same reduction in speeding as did the ISA - equipped groups. The observed increase in the speeding of the control group was not found to be statistically significant, but the speeding of the incentive group did decrease. Compared with the test phase, the decrease in speeding in the first experimental period was small and it was not statistically significant, but in the second period of the experiment, the reduction was found to be statistically significant ($P = 0.0002$).

4 Concluding remark

The present study was originally planned for 300 volunteers, but, because of unexpected problems with the recruitment of young volunteers for the ISA project, the first results included only few subjects. Young non-volunteers were also difficult to recruit for the survey. The survey revealed few differences between young volunteers and young non-volunteers. Apparently, only one issue separated the two groups: the judgement of ISA. This difference was not due to any actual experience with ISA, since the volunteers had not had the ISA system switched on prior to responding to the survey. It is tempting to speculate that the observed difference in attitude to ISA may have reflected the decisions already taken by the respondents, and therefore the volunteers may seek a justification of their effort, whereas the non-volunteers would need to justify their resistance to volunteer. The random assignment of the volunteers to different ISA treatments demonstrated that two treatments were superior: informative ISA and informative ISA in combination with an incentive for not speeding resulted in a substantial reduction in the amount of speeding. The fact that the presence of the incentive did not add to the effect of informative ISA may be due to a floor effect. Although speeding did not quite disappear, informative ISA reduced speeding too much for the incentive to increase the gain. As the incentive alone, for example, incentive without informative ISA,

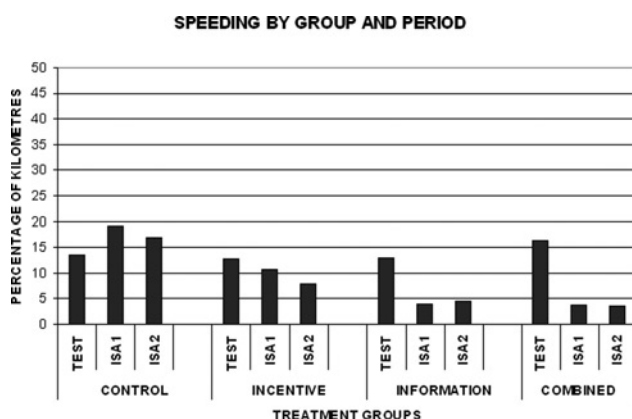


Figure 5 Percentage of kilometres driven at a speed above the activation level of the ISA system (limit + 5) by group in the test period (TEST) and in two consecutive experimental 6-week periods with ISA switched on (ISA1) and (ISA2)

Notice that two groups, the control group and the incentive group, drove without ISA switched in the test period as well as in the experimental periods

proved to reduce speeding, driver motivation may play a role and the incentive may be important for the maintenance of the positive effects of informative ISA over longer time periods.

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