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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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# EFFECTS OF ISA ON THE DRIVING SPEED OF YOUNG VOLUNTEERS: A CONTROLLED STUDY OF THE IMPACT INFORMATION AND INCENTIVES ON SPEED.

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## ABSTRACT

The present study is a part of the ISA PAYD project being conducted in the County of North Jutland, Denmark. The first part of the study compared background data and attitudes between young ISA-volunteers and non-volunteers. Volunteers and non-volunteers differed only with respect to their judgement of ISA effects. The second part of the study compared effects of ISA on speeding for ISA-volunteers exposed to different combinations of informative ISA and incentives e.g. speed dependent insurance discounts. Comparisons of amount speeding between treatment groups showed that ISA in combination with incentives and ISA alone reduced speeding, incentive without ISA had some effect on speeding whereas the control group, which neither had ISA or incentives continued to speed throughout an observation period of 18 weeks.

**KEYWORDS:** Safety attitudes, ISA volunteers, Incentive, Informative ISA, Field experiment.

## INTRODUCTION

Intelligent Speed Adaptation (ISA) is a case of Advanced Driver Assistance System (ADAS) with a great safety potential; ISA addresses a core variable in safe driving, driving speed, and it does not interfere with the drivers' higher order task control [1]. Compared with conventional road information ISA has also clear advantages: ISA displays the current legal speed limit continuously during driving and prompts the driver in case that the speed limit is exceeded. Thus, ISA prevents the driver from unintended speeding. As ISA equipment comes with different interfaces interface design has been an important issue in many previous studies. Most often ISA is described as being informative, interactive or mandatory. Interactive and mandatory ISA is usually associated with an active gas pedal whereas informative ISA mostly uses combinations of visual and auditory speed warning messages [2][3]. Apart from some initial small scale experiments several long-term field studies have already been completed with different types of ISA technologies and interfaces and with no exception, the studies have reported

positive effects of ISA on speeding (see [2][3] and [4] for recent extensive reviews of previous ISA field-studies) moreover only positive effects on general driving behaviour has been observed [5][6]. ISA has been found to reduce mean speed, speed variance and the time driven at a higher speed than the activation level of the system. Recently, however, Warner [4] reported attenuation of the beneficial effects of ISA after long-term exposure and tendencies to override mandatory ISA, if possible, has also been reported [7]. Such results suggest that volunteers encouraged by ISA to comply with the speed limit may still sometimes find reasons for deliberate speed violations. This fact draws attention to G. Wildes controversial conjecture [8] that driver motivation i.e. a change in the target level of risk, is essential to improvement of traffic safety. In fact, the impact of safety technologies depend very much on the way such technologies are actually used [9]; obviously human factors issues are highly relevant to any safety technology including road traffic and ISA. The use of volunteers is an inherent problem and presumably an unavoidable condition in many studies of new vehicle technologies. Obviously volunteer-bias may be a result of both unrepresentative driver samples and of the volunteers' motivation and attitude to speeding. Even volunteers with a negative attitude to ISA [10] but accepting to volunteer could be more compliant than the majority of drivers if forced to drive with ISA. As the use of volunteers in ISA studies is unavoidable the qualification of obtained results depends on the use of scientific standard procedures, since overestimation of the efficiency of safety measures is more likely in studies with a weak control of confounding variables [11]. The main focus of many ISA studies has been feasibility and reliability of different technologies. Effort has been devoted to human factors issues but apparently selection and recruitment of volunteers have received less attention and control conditions, apart from before-after comparisons, have been absent in most ISA studies. Moreover the majority of ISA volunteers have been mature and experienced drivers and most often volunteers have had other car options than the use of an ISA-equipped vehicle. The present study differs from previous ones on several respects: By focusing mainly on young drivers - a driver group known for their high accident risk, for their lack of driving experience and for speeding - by using control groups and by exposing volunteers to different ISA treatments. The present paper aims at a clarification of two human factors issues (1) the possible differences between volunteers and non-volunteers in their attitudes to speeding and (2) the relative impact on young drivers speeding of ISA-information and of incentives for not speeding. While informative ISA encourage compliance with legal speed limits incentives is associated with economic gain for behaving appropriately [12].

### **The “Pay as You Driver” (PAYD) Project**

The present study was a part of a current ISA project, “Pay as You Drive” (PAYD), which is a follow-up to the previous INFATI project [13]. The PAYD concepts differs from the INFATI project in several respects, (1) it addresses young car owners, (2) it combines ISA with incentives for compliance with the legal speed limit (3) it uses an extended road network with GPS-based ISA surveillance (4) it requires volunteers commitment for 3 full years and (5) the first 6 month of the project period forms an experiment in which volunteers are exposed to different ISA-treatments. Specifically, the present study is concerned with the effect of ISA on the speeding of car-owners aged between 18 and 28 years in a road network of approximately 22.000 km with ISA coverage of all speed limits. ISA volunteers were also offered incentives: They would

receive a discount of 30% on their car insurance provided they refrained from exceeding the speed limit in the project period.

## **METHOD**

The study contains two parts; (1) a questionnaire including volunteers as well as non-volunteers from the same population of young car owners in the County of North Jutland and (2) an experiment with young volunteers being exposed to different ISA-treatments during their first 6 months of driving with ISA in the PAYD project.

### **Equipment**

The ISA equipment consisted of an on board unit (OBU) for communication with external devices, a display showing the current speed limit, and a voice message telling the current speed limit and that “You are driving too fast” in case of exceeding the legal speed limit with more than 5 km/h for more than 6 sec. The voice message would be repeated each 6<sup>th</sup> second unless speed was lowered to the limit. By activation of the third voice message the count of “penalty points” would start, which generally followed the Danish speed ticket system. This takes into account the degree and duration of speeding and the road type. Each penalty point reduced the discount with 7 cents. Calculation of the discount reduction was done and accessible to the volunteers overnight.

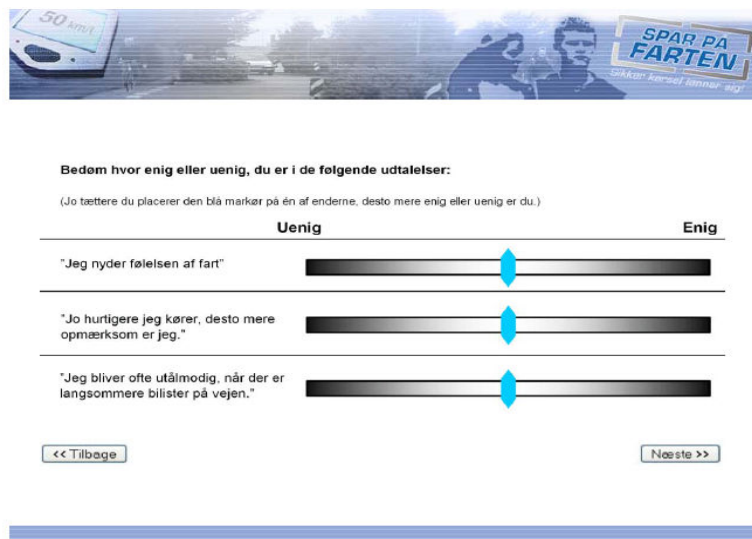
### **Recruitment of volunteers**

The recruitment of young volunteers started late 2005 and aimed at including 300, preferably young, car owners. All car-owners in the County of North Jutland aged between 18 and 28 years were invited to volunteer in the PAYD project. A letter with an invitation to participate in the PAYD project was sent to 11.400, car-owners in the relevant age group. The letter exhorted the recipients to sign-on to the project via the PAYD web-site. After signing-on a project official would contact them. They were also informed that the project would last for 3 years that they would receive 30% discount in their car insurance for participating and how the penalty system would work. Volunteers were required to have or to change to a certain insurance company, “Topdanmark”. By April 2006 a total of 220 recipients had signed-up and were contacted for contract assignment and instalment of the on board unit (OBU); however by September 2006 only 50 had actually signed the contract. The first 8 volunteers had their OBU installed in May 2006 and served as test drivers for evaluation of system reliability and are not included in the experiment.

### **Experimental design**

In the first 1 ½ month period after the OBU had been installed the display and the voice message were switched off in order to observe and log the volunteers’ unsupported speed. The next 4 ½ month were the experiment period with participants randomly assigned to one out of 4 predefined ISA treatments: The “*internal control group*” continued to drive without ISA display and voice message and they would not get penalty points for speeding. This group formed the control group, since they accepted to volunteer but their

speed could neither be affected by display, voice messages or reduced insurance discount. The “*incentive group*” also continued to drive without ISA display and without voice messages but anyway their discount would depend on their speeding. This group would use conventional road signs for their information and only their motivation to obtain the insurance discount could affect their speed behaviour. The “*information group*” had ISA display and voice message but would not get penalty points for speeding. This group would be encouraged not to speed by the voice message, but they would not be motivated by the incentive. The “*combined group*” both had ISA display, voice message and discount depended on their speed behaviour. This treatment was the one originally planned in the PAYD project and all the volunteers would be transferred to this treatment after the experiment.



**Figure 1: The Graphic Layout of Questionnaire Screens. Extremes of the Continuous Scale on This Figure are: “Disagree” – “Agree”.**

## Questionnaire

After having ISA installed and before having ISA activated volunteers were required to fill-in a questionnaire. A selection of young car owners from the same population that had not responded to the first invitation after 6 month, were invited to fill in the same questionnaire as the volunteers. Letters were sent to a total of 1.973 non-participants, selected on the basis of their day of birth. They were asked to fill in the questionnaire and were offered a chance to win a lottery with 3 gift vouchers of a value of 430 euro. This letter resulted in a total 54 correctly completed questionnaires from non-participants in the relevant age group. The questionnaire was managed via the project web-site and could be accessed by respondents with a code. Background questions included driver license data, driving experience and educational background. The questionnaire addressed a number of themes: Driving speed, risky traffic behaviour, driving style, judgement of ISA features, and anticipation of the possible effects of driving with ISA. The questionnaire was a remix of “most frequent questions” from similar questionnaires used for investigating driver attitudes including [14] [15] [16] [17]. Using the opportunities of a web-questionnaire the Likert scale values – that are usually not consistently used between questionnaires – were transformed to a continuous scale with a

moveable pointer (see figure 3). Scale values were not visible to respondent but were subsequently transformed to values ranging from -200 - +200.

## RESULTS

### Questionnaire Data from Volunteers and External Controls

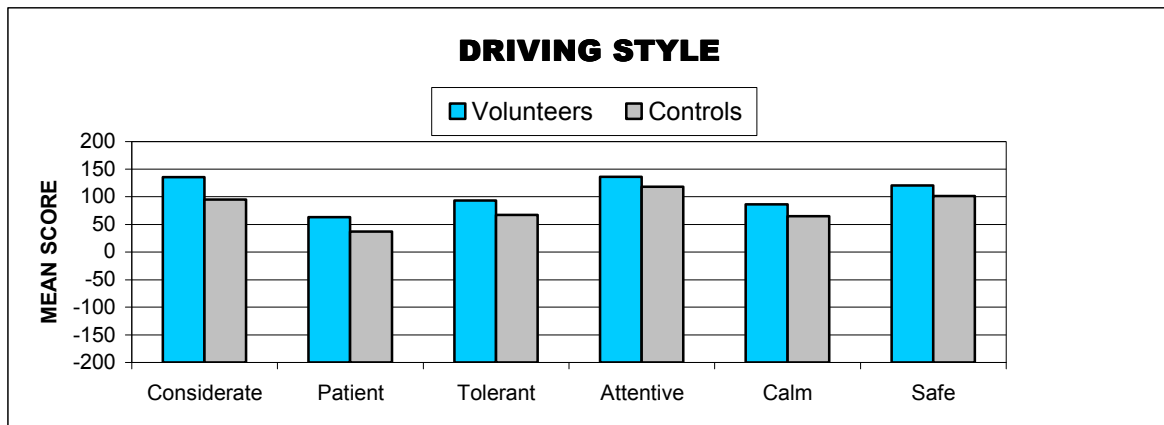
Analysis of background variables revealed that the two groups, 32 volunteers and 54 non-volunteers, very similar with respect to share of gender, age and the three indicators of driving experience, licence data, duration of car ownership an mileage. The between group differences were small and none of them were statistically significant.

	Share of Gender Percentage	Year of Birth Mean	Driver Licence Months	Car Ownership months	Mileage Last Year Km
<b>Volunteers</b>					
males	71.9	1982	67.0	47.5	21,408
females	28.1	1982	70.0	36.6	13,055
<b>Controls</b>					
males	70.4	1981	81.6	46.8	19,187
females	29.6	1981	83.7	51.0	10,337

**Table 1: Summary of Background Factors in the Two Groups.**

### Self reported Driving Style

The reported Driving Style of volunteers and non-volunteers showed similar tendencies; both groups scored themselves high on a scale with extremes being contrasts considerate-inconsiderate, patient-impatient, tolerant-intolerant, attentive-inattentive, calm-annoyed, and safe-risky drivers (see figure 4.).



**Figure 2: Self Reported Driving Style on a Contrast Scale with Zero as the Neutral Point.**

Taken as a whole, volunteers scored themselves more on the positive side than did the non-volunteers. Despite the fact that the difference for each individual item were small and none of the differences were statistically significant, the general tendency, more positive scores in 6 out of 6 items for the volunteer group was tested with a sign test and was statistically significant ( $p < .02$ ).

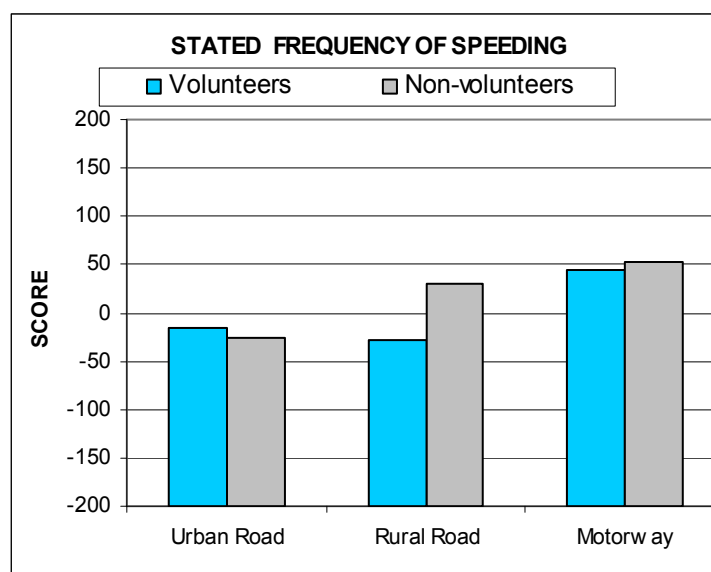
### Attitudes to speeding and speed limits

A number of different questions addressed attitude to speed; respondents were required to propose an appropriate legal speed limit for the road types: Urban roads, rural roads and motorways of which the basic speed limit in Denmark are 50 km/h, 80 km/h and 130 km/h respectively. In line with previous findings [14] the majority indicated the actual speed limit for urban roads and motorways whereas they proposed higher legal limits, ranging from 90 km/h to 180 km/h for rural roads (see table 2).

	Urban Road < 50 >			Rural Road < 80 >			Motorway < 130 >		
<b>Volunteers</b>	3.1	84.4	12.5	0	21.9	78.1	12.5	65.6	21.8
<b>Controls</b>	9.2	77.8	13.0	0	18.5	81.5	16.7	50.0	33.4

**Table 2. Percentage of Young Drivers, who Proposed a Lower, the Current or a Higher Speed Limit.**

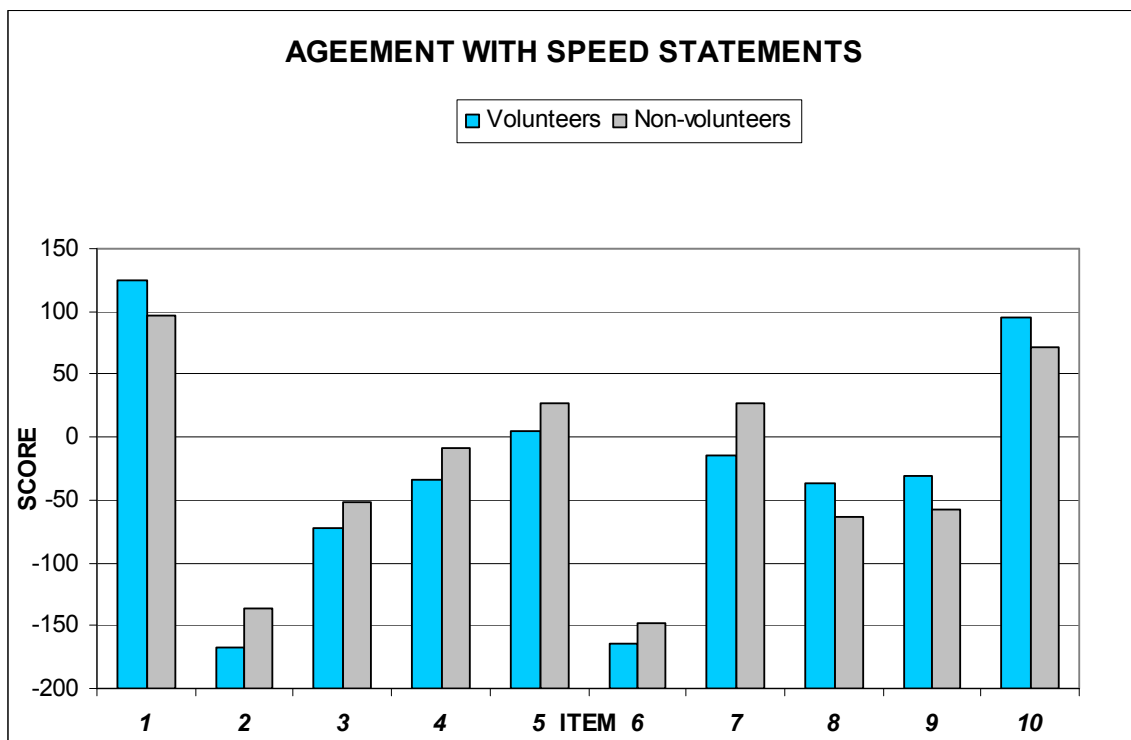
However, the indications on the frequency of speed violations on the three road-types with “seldom” and “often” as extremes did not really reflect this assessment. The difference between the two groups in their stated speed violation frequency were analysed by a one way ANOVA showing that the difference between the two groups for rural roads was actually significant ( $p < .05$ )



**Figure 3: The Stated Frequency of Exceeding the Speed Limit on Different Road Types on a Scale from often (+200) to seldom (-200).**

The young drivers peed attitudes were further approached with 10 statements about speed requiring respondent to indicate their agreement or disagreement with each statement (see Figure 7):

- (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 speed limits”*
- (7) *“Speed limits are virtually unnecessary in traffic”*
- (8) *“If I am busy I may take a chance in traffic”*
- (9) *“If I was sure of not being caught I would driver faster than I usually do”*
- (10) *“I sometimes feel a pressure in traffic to driver faster than enjoy”*



**Figure 4: Indications of Agreement (+200) or Disagreement (-200) on the 10 Speed Statements Presented above the Figure.**

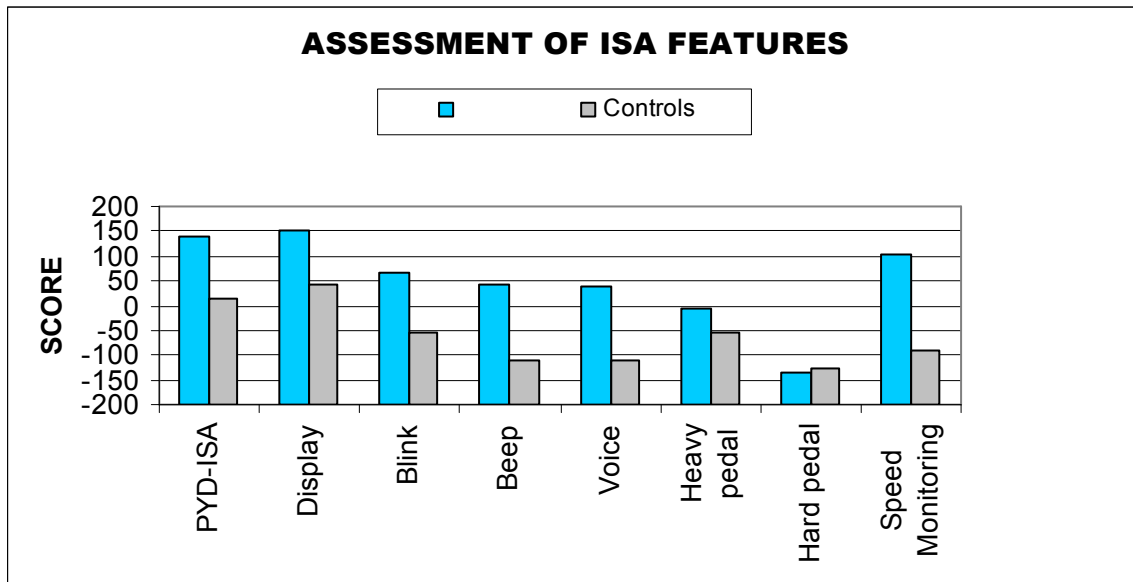
Differences in the judgement of single items between the two groups were tested with a one-way ANOVA and, as a matter of fact, none of them were statistically significant, which may be due to the small sample size.

### **Assessment of ISA Features and Effects of using ISA**

ISA volunteers and external controls differed considerably in their judgements of ISA features (Figure 8). All differences were tested with a one-way ANOVA and all



differences were found highly significant (all:  $p < .001$ ) except two: Volunteers and non-volunteers agreed on the negative evaluation of The “heavy” and the “hard” gas pedal, usually associated with interactive and mandatory ISA. Expectedly the system used in the present project (PAYD-ISA) was judged more positive by volunteers than by non-volunteers.

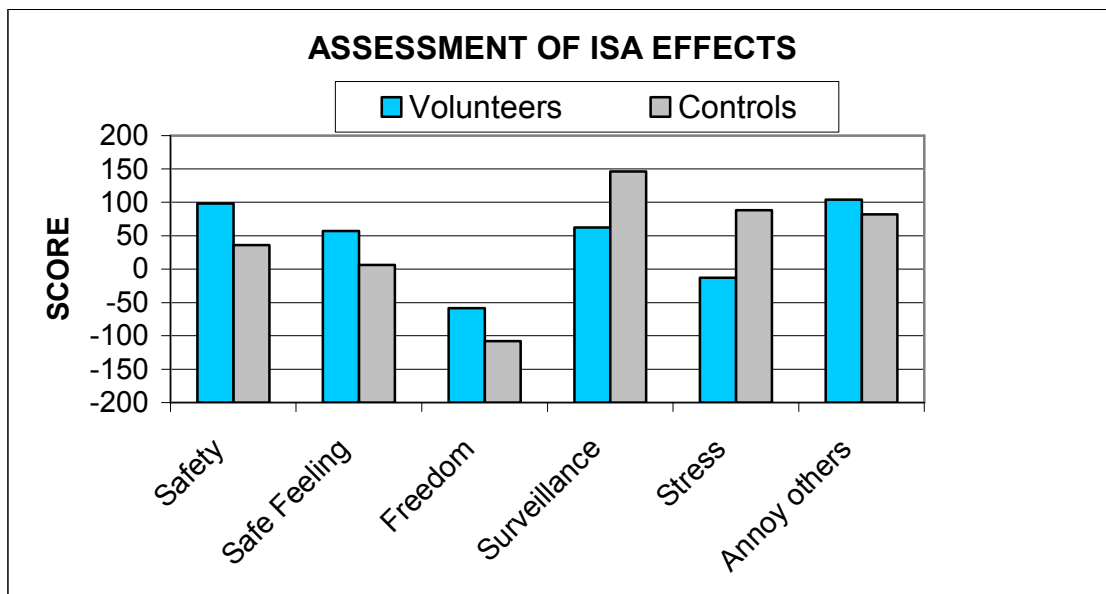


**Figure 5. Positive (+200) and Negative (-200) Assessments of ISA-features Including the ISA PAYD System.**

Also judgements of possible impacts of driving with ISA differed between groups; not surprisingly the scores of ISA volunteers were higher on positive effects and lower on negative effects whereas the pattern of non-volunteers was reversed. The differences between groups were tested with a one-way ANOVA and were found significant (all:  $p < .008$ ) except volunteers and non-volunteers agreed that driving with ISA they could annoy other drivers.

### Discussion of Results from the Questionnaire

Volunteers and non-volunteers were actually very similar with respect both to their background, their stated driving style and their attitudes to speed. Volunteers did not differ from non-volunteers on any single items concerning attitudes to speed however a general tendencies of volunteers to be a little more on the “safe” or the “cautions” side can be noticed. With respect to assessment of ISA-features and anticipated effects of driving with ISA the differences in judgements between the two groups were generally highly significant. Only volunteers and non-volunteers were consistent in their negative judgement of active gas pedal and in anticipating that driving with ISA could annoy other drivers. In fact volunteers were more positive to ISA-features than were non-volunteers and they anticipated more positive effects of driving with ISA. It is worth noticing, however, that non-volunteers were neutral, rather than negative, in their judgement of the (description of) the ISA-system used in the present project.



**Figure 6. Anticipated Increase (+200) or Decrease (-200) for 6 Items Related to Driving with ISA.**

### Driving Data for Volunteers in Different ISA-Treatment Groups

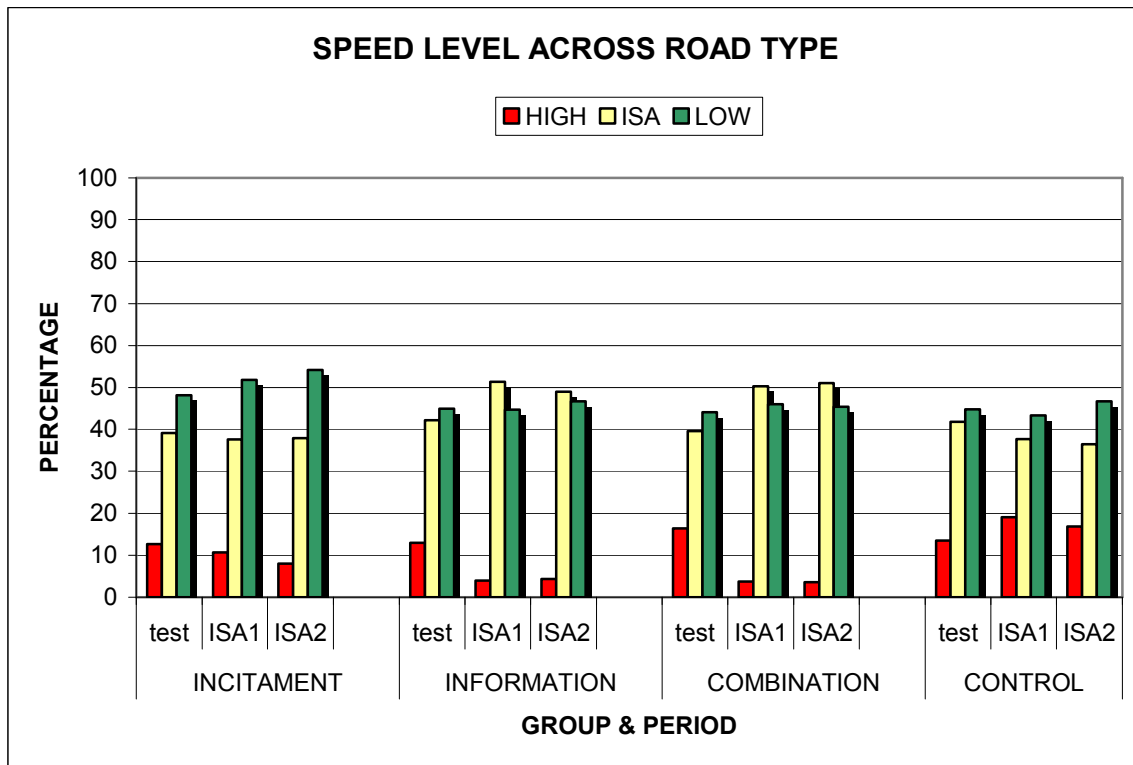
Driving data used in the present analysis was based on 31 volunteers with complete speed registrations in the relevant time period; eight from the control group, seven from the incitement group, seven from the information group and nine from the combination group. The analysis included three 6-week periods: The test phase (test), and two periods of the same duration (ISA1 and ISA2) of the experimental phase. Driving data from week 7 was excluded since the transition from test-phase to driving with ISA period took place during that week. The total distance driven in each period varied considerably between groups and so did the distances driven at a higher speed than the activation level of the ISA system (see table 3.).

	TEST		ISA1		ISA2	
	Total	Over	Total	Over	Total	Over
<b>Incentive</b>	15513	2877	14078	1998	11164	850
<b>Information</b>	15021	2583	14354	548	14646	648
<b>Combination</b>	18973	3630	20113	335	18393	334
<b>Control</b>	12376	2486	13231	3476	11927	2850

**Tabel 3. Total Distance Driven and the Distance Driven over the ISA-activation Level in three Periods by Volunteer Group.**

The variance in distances driven between groups and time periods was accounted for by using the percentages of the total distance driven at different speed levels in the further analysis; a "low" level indicates the distance driven with a speed lower than -5 km/h below the current speed limit, a "ISA" level which is between - 5 km/h below to the ISA activation level e.g. 5 km/h over the legal speed limit, and finally a "high" level which is

over the ISA activation level and thus more than 5 km/h over the legal speed limit. Figure 7 show the distribution of distances driven within the different speed level.



**Figure 7. Percentage of Kilometres Driven at 3 Speed Levels by the Volunteers Receiving Different Treatments.**

The figure suggestively indicates that the share of distances driven with a speed over ISA activation level decreases for the two ISA equipped groups being encouraged not to exceed the activation level of the system. The effect of incentive is less clear but apparently incentive alone affected speeding by a small amount. The control group however, which was neither encouraged by ISA display or voice messages nor motivated by the size of the incentive did not change the share of speeding - at least not in the positive direction. The share of high speeds registered for each individual over the 18 weeks observed in this study, were submitted to a two-way ANOVA with group as a between-subject factor and period as within-subject factor. The analysis revealed a significant main effect of group ( $F= 67.9$   $df= 3,3450$   $p< .0005$ ) and period ( $F= 44.6$   $df=2,3450$   $p< .0005$ ) and also a significant interaction between these two factors suggesting that the groups differed with respect to the share of high speed over the three periods. Pairwise comparison of between group differences revealed that the groups were different significantly different with respect to speeding except the “combination” group and the “information” group. A subsequent one-way ANOVA was used for comparing speeding over period within groups. This analysis revealed a statistically significant difference in speeding between the test period and the two ISA periods for the “information” and for the “combination” group (both:  $p = .0005$ ) and no difference between the two ISA periods. Even the speeding of the “incitement” group changed, this group had a significant difference in speeding between the test period and the ISA2

period ( $p = .0002$ ). The speed difference of the control group between periods was not statistically significant.

## **DISCUSSION**

The present study was originally planned for 300 volunteers but due to lack of response to the project from young car-owners data available for the present study was from only 31 volunteers. However even with a small sample it was demonstrated that the young volunteers participating in the PAYD project similar to the 54 young non-volunteers with respect to their background experience, stated driving style and general attitude to speeding and legal speed limits. Despite the small sample the difference between the two groups in their judgements of ISA features and the anticipated effects of driving with ISA were actually statistically significant suggesting either a justification of effort of the volunteers or possibly a strong opinion against ISA of non-volunteers. However, the whole sample, 86 subjects, is less than 1% of the population addressed in this study. Exposing the volunteers to different treatments demonstrated that informative ISA has a substantial effect on speeding. The effect of the incentive is less clear in the present study: We may speculate that since incentive alone had an effect on speeding it could incentives could be a way of preventing attenuation of the speed reducing effect of ISA after long term use of the equipment.

## **A CONCLUDING REMARK**

In this small sample and over this short period it was not possible to establish an effect of combining ISA with incentives. The PAYD project is still a young project with few volunteers. The present study covers only a relatively short observation period in the first year of PAYD project. Obviously, more subjects, and longer observation period is required for a consolidation of the results and for establishing the possible effect of combining ISA with incentives. ISA is still a driver assistance system with a great safety potential though its potential is dependent on drivers' willingness to use the system and comply with it.

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