Driver comprehension and acceptance of the active accelerator pedal after long-term use

Emeli Adell *, András Várhelyi

Department of Traffic Planning and Engineering, Lund University, Box 118, 221 00 Lund, Sweden

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Abstract

Driver comprehension and acceptance of the active accelerator pedal (AAP) after long-term use were evaluated in a large-scale Swedish trial held in 2000–2002. The system was installed in the cars of 281 test drivers who then used it for between six months and a year. The participants’ responses, elicited by questionnaires in the end of the trial, showed a positive rating of the concept of the AAP, while the willingness to pay for it was lower than for other driver-assistance systems studied elsewhere. The typically skeptical driver was a young, male, company car driver with initially negative attitude and a faulty AAP. The typically enthusiastic driver was an older, female, private driver with initially positive attitude and a fault-free AAP. The drivers found that the system, if not satisfactory, was useful but added to the emotional pressure felt by the driver. However, they did think it had positive impacts on performance and safety. Still, the largest perceived effect was a decrease in the risk of being fined for speeding. The gap between the concept of the AAP and willingness to keep and pay for the system puts a clear focus on the importance to define acceptance and developing a tool to ensure reliable assessments of it.

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Keywords: Active accelerator pedal; Speed management; Field trial; Driver comprehension; Acceptance

1. Introduction

Speed management has become a major focus of research due to the proven strong relationship between speed and accidents that has been reported in several studies over the years (see e.g. Elvik & Vaa, 2004; Finch & Kompfner, 1994; Nilsson, 2004; Salusjärvi, 1981). In response to these findings, speed management has concentrated on measures related to the road and its environment (e.g. humps, narrowing of streets) and to the driver (e.g. enforcement). While these measures have successfully reduced speeds at isolated sites, the extent of spatial speed reduction is still very small (see e.g. Hydén & Várhelyi, 2000; Østvik & Elvik, 1990; Teed, Lund, & Knoblauch, 1993).
Speed management via in-car devices has been researched since the 1980s and various systems have been developed and tested. Experiments with tactile systems, such as the speed limiter and the dead throttle (voluntary or mandatory), have demonstrated positive effects on speed level and speed variance in field trials (Almqvist & Nygård, 1997; Duynstee, Katteler, & Martens, 2001; Saad & Malaterre, 1982; Várhelyi & Mäkinen, 2001) and simulator studies (Comte, 2000; Comte & Jamson, 2000; Godthelp & Schumann, 1991). The almost unanimous conclusion is that some aspects of negative behavioural adaptations and the long-term effects on compliance and acceptance in real traffic need more research. One expected positive advantage of tactile feedback, compared to visual information and feedback, is that the driver will not have to look at the speedometer or the speed limit display to the same extent, giving him/her more visual capacity for other driving tasks. Nilsson and Berlin (1992), investigating the effects of speed limit information via a visual display on the dashboard in a field trial, found that the number of glances at the dashboard was on average 3 times higher compared to driving without it. They also found that the average speed was higher with the system than without it, statistically non-significant, but still an increase. In a comparative simulator study of speed limit information via an in-car display, speed limiter and infrastructural measures, Comte and Jamson (2000) found that all three reduced the speed level on curve approaches, but the speed limiter had significantly larger effects than the others. A field trial, measuring effects of a visual feedback display on speed limit compliance, by Brookhuis and de Ward (1999) showed that the subjects in the experimental group complied more with traffic rules than subjects in the control group.

Surveys involving the public have shown a relatively good acceptance of the concept of in-car systems for speed management. Várhelyi (1996) found that one-third of the participants in a Swedish survey were positive to an automatic speed limiter. The SARTRE European survey revealed that such systems were perceived as useful by a majority (Dahlstedt, 1999) and more acceptable as a voluntary than a mandatory system (Dahlstedt, 1994). However, as Levelt (1997) points out, there might be differences between attitudes based on expectations and those based on experience. Drivers testing the system in a Swedish field study generally displayed positive attitudes towards the speed limiter, and considered the function more positive than expected before the trial (Almqvist & Nygård, 1997). A field trial with a speed limiter in the Netherlands disclosed that mixing speed-limited vehicles with ordinary vehicles could create some irritation among the drivers (Duynstee et al., 2001). Other field studies in The Netherlands, Spain and Sweden indicated that drivers sometimes experienced higher frustration levels when driving with the speed limiter (Várhelyi & Mäkinen, 2001). The most frequently mentioned disadvantage of the speed limiter was the fact that it was impossible to exceed the speed limit, even in emergency situations. By emergency situation most drivers meant overtakings. It was also found that voluntary systems were more acceptable than mandatory systems (Várhelyi & Mäkinen, 2001). In another field trial in Finland (Päätalo, Peltola, & Kallio, 2001) comparing three types: an informative system, a speed limiter and a recording system, it was concluded that the limiting system was the most effective in reducing speeds, but that the informative one had the highest acceptance. In a simulator study of three levels of speed control (advisory, limiting and extended limiting – also in hazardous conditions), Comte (2000) found that drivers thought the limiting system would be the most useful, but they preferred the idea of a voluntary system. In a comparative simulator study Comte and Jamson (2000) showed that the speed limiter brought about the largest speed-reducing effect. In terms of the acceptability, however, it was least preferred compared to in-car speed information and infrastructural measures. Comte, Wardman, and Whelan (2000) reviewed studies that used a variety of techniques to evaluate the acceptability of speed limiters, investigated acceptability in terms of usefulness, pleasantness, ease of use, whether the drivers would purchase the system and how much they would be willing to pay. They concluded that “drivers’ opinions about the system do not change with familiarity with it” and “drivers were not more negative after their experience with the system”.

While these earlier studies have provided some insights into behavioural effects, as well as perception and acceptance of speed limiters, dead throttles and visual displays, none have evaluated the active accelerator pedal (AAP) system. The AAP, compared to the speed limiter and dead throttle, is a more lenient, overrideable support system with a probable higher acceptance by the driver population. Such an “Intelligent Gas Pedal” has in fact been studied as part of a collision avoidance system. In a driving simulator experiment Nilsson, Alm, and Janssen (1992) found that the use of the “Intelligent Gas Pedal” was “relatively free from negative side effects” and incurred no increase of workload. These findings indicate that it is worthwhile to test driver comprehension of and reactions to the AAP as part of a speed support system.
The earlier studies have also been small scale, with a few participants, which makes useful comparison between driver groups hard, and the representativeness of the selected test drivers difficult to determine. Furthermore, since these studies were carried out after very short accommodation periods, none of them could investigate long-term driver experiences with in-vehicle speed support systems. The time a system has been in use may have an impact on its effects with initial speed reduction fading over time (see e.g. Hydén & Várhelyi, 2000). Thus, there is a risk of overestimating the effect of the system if it is only evaluated after short-term usage. Assessing the acceptability and potential use of any driver-assistance system requires accurate data on driver comprehension, acceptance and willingness to pay for it based on everyday use and a sufficient accommodation period.

The aim of this paper is to assess driver comprehension and acceptance of the AAP after long-term usage. Differences between driver groups are also analysed.

2. The trial

The trial was part of the Swedish Road Administration’s large scale assessment of Intelligent Speed Adaptation (Vägverket, 2002; Várhelyi, Hjälmåsdahl, Hydén, & Draskóczy, 2004).

2.1. The system

The system is based on a GPS receiver, which continuously identifies the position of the vehicle, and a digital map containing all the current speed limits within the test area. The interface with the driver consists of a display (see Fig. 1) showing the current speed limit, and an active accelerator pedal that exerts a counterforce at speeds over the speed limit. In order to exceed the speed limit the pedal must be pressed approximately three to five times harder than normal.

The vehicles were also equipped with a data-logger that recorded, among other things time, position and speed. The vehicle does not transmit a signal of its own and cannot be localised.

The installation of the AAP in the 281 test vehicles was carried out from November 2000 till May 2001. After data collection for evaluation, the dismantling of the AAPs started in November 2001 and went on until January 2002.

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Fig. 1. The active accelerator pedal (or Limit Advisor as the manufacturer calls it) with its components (published with the kind permission of IMITA AB).
2.2. The test area

The test area consisted of the entire city of Lund (100,000 inhabitants) and included 30, 50 and 70 km/h speed limits (see Fig. 2). The system was activated automatically when the vehicle was within the test area and could not be turned off. Outside the test area the driver could activate the system manually and set it to a desired speed limit.

2.3. The test drivers

The 281 participants (247 private car drivers and 34 company car drivers) were recruited by questionnaires distributed to (1) randomly-selected vehicle owners in the municipality of Lund and (2) local companies. The test drivers were divided into groups according to gender, age and initial attitude, i.e. positive/negative/undecided, towards the active accelerator pedal. The initial attitude was established by the question “What would your opinion be to having the following system in your car? A system that gives a counter force in the accelerator when the vehicle has reached the speed limit, and the speed limit cannot be overridden except in an emergency.” (good, not good, neither) in the recruiting questionnaire. Of the 281 who started the trial, 197 completed it, see Table 1.

Female drivers over 65 and young drivers (18–24) were underrepresented. This was due to the fact that female drivers over 65 often do not have a car registered in their own name, and young drivers often have older cars in which it was not possible to install the AAP. Middle-aged drivers (45–64) were overrepresented.

![Fig. 2. The test area, the city of Lund with 30, 50 and 70 km/h speed limits.](image-url)

### Table 1

<table>
<thead>
<tr>
<th>Age group</th>
<th>18–24</th>
<th>25–44</th>
<th>45–64</th>
<th>65≤</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>–</td>
<td>?</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>4/2</td>
<td>2/1</td>
<td>1/1</td>
<td>41/26</td>
</tr>
<tr>
<td>Female</td>
<td>5/3</td>
<td>0/0</td>
<td>0/0</td>
<td>26/19</td>
</tr>
<tr>
<td>Total</td>
<td>9/5</td>
<td>2/1</td>
<td>1/1</td>
<td>67/45</td>
</tr>
</tbody>
</table>
There were some technical problems, with two thirds of the drivers reporting some level of system failure during the trial. Of these, company car drivers (32 of the 34 drivers, $X^2, p < 0.05$) were overrepresented. No differences in gender ($X^2, p = 0.29$), age group ($X^2, p = 0.47$) or initial attitude ($X^2, p = 0.99$) could be found.

3. Method

3.1. Experimental design

The evaluation was designed to be a long-term one. The system was installed in the participants’ private cars or company cars regularly used for between 6 and 12 months.

3.2. Procedure

Responses were elicited by questionnaires mailed to the drivers when the system was dismantled. If no reply was received after three weeks, a reminder was sent out. As compensation for time loss and inconvenience, the drivers received 99 SEK (~10€) in petrol checks twice during the trial.

3.3. Questionnaires

The questionnaire covered: system features, perceived effects on themselves as drivers (performance, driving enjoyment, stress, etc.) and perceived effects on driving outcome (safety, speed, travel time, etc.). In total, the drivers answered 229 questions in the long-term questionnaire. Most questions were to be answered on a five-graded scale (either one sided or two-sided), but seven-graded scales and open questions were also used.

The response rate was 85% (168 of 197 drivers). There were no statistically significant differences in response rates with respect to gender ($X^2, p = 0.95$), age groups ($X^2, p = 0.34$) (drivers 18–24 were too few to be assessed), initial attitude ($X^2, p = 0.48$) or driver type ($X^2, p = 0.34$).

3.4. Analysis

Analysis of variance (ANOVA) was employed to analyse the data of variables when no severe deviations from a symmetric distribution were found. The design 3 (age)×2 (gender)×3 (initial attitude)×2 (driver type)×2 (system failure), was used. Main effects and 2-way interactions of the between-subject factors AGE (25–44, 45–64, 65+), GENDER, INITIAL ATTITUDE (positive, negative, undecided), DRIVER TYPE (company car drivers, private drivers) and SYSTEM FAILURE (fault-free, faulty) were entered in the univariate ANOVA model. Backwards elimination was used until $p < 0.10$. Differences among age groups and attitude groups were found with the use of Post Hoc pair-wise comparison (Bonferroni). The single sample $t$-test was employed to analyse differences from the answer category “unchanged”.

The Mann–Whitney’s rank sum test was employed to analyse effects of gender, driver type and system failure when symmetric distribution of the data could not be assumed, and the Kruskal–Wallis H was used for differences between age groups and groups with different initial attitudes. Statistically significant differences among more than two groups were identified by means of Post Hoc pair-wise comparison (Tamhane).

Since only two responded from the youngest age group (18–24) this group had to be excluded.

4. Results

4.1. The concept of the AAP

The concept of the AAP was regarded positively by a majority of the drivers, see Table 2. Statistically significant effects of initial attitude and driver type were found, showing that initially positive drivers were still more positive to the idea of the AAP in the long term than initially negative drivers (Kruskal–Wallis, $H(2) = 9.559, p < 0.05$, Post Hoc $p < 0.05$) and that private car drivers were more positive to the concept than company car drivers (Mann–Whitney, $U(n_1 = 18, n_2 = 142) = 910.5, p < 0.05$).
4.2. System features (as communicated by the drivers)

The AAP was considered to be “good” rather than “bad” ($M = 0.94$, $SD = 1.610$, where $-3 = \text{bad}$ and $+3 = \text{good}$) and “important” rather than “unimportant” ($M = 1.26$, $SD = 1.427$, where $-3 = \text{unimportant}$, and $+3 = \text{important}$), see Fig. 3. The Mann–Whitney test showed that drivers with a fault-free system regarded the AAP to be better than drivers with a faulty system did ($U(n_1 = 52, n_2 = 110) = 2179.0, p < 0.05$). The analysis also indicated that company car drivers and drivers with a faulty system thought the system was less important than did private car drivers ($U(n_1 = 18, n_2 = 145) = 979.0, p < 0.10$) and drivers with a fault-free system ($U(n_1 = 52, n_2 = 111) = 2351.5, p < 0.10$) respectively. The younger drivers also thought the system was more “irritating” than other drivers did ($F(2,153) = 6.581, p < 0.05$, Post Hoc $p < 0.05$), initially positive drivers ($F(2,153) = 2.691, p < 0.10$, Post Hoc $p < 0.10$) and drivers with a fault-free system ($F(1,156) = 7.268, p < 0.05$). The opinion on the aesthetics of the system was influenced by initial attitude, system failure and the interaction between initial attitude and age. Initially positive drivers and drivers with a

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**Table 2**
The concept of the AAP after long-term usage, by attitude toward the system before the trial and driver type

<table>
<thead>
<tr>
<th>“What do you think of the concept of the AAP?”</th>
<th>All drivers ($N = 160$)</th>
<th>Initial attitude</th>
<th>Driver type</th>
<th>Company ($N = 18$)</th>
<th>Private ($N = 142$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive ($N = 104$)</td>
<td>Negative ($N = 22$)</td>
<td>Undecided ($N = 32$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very bad ($−2$)</td>
<td>1.9%</td>
<td>1.0%</td>
<td>0.0%</td>
<td>6.3%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Rather bad ($−1$)</td>
<td>6.9%</td>
<td>3.8%</td>
<td>13.6%</td>
<td>9.4%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Neither ($0$)</td>
<td>12.5%</td>
<td>9.6%</td>
<td>27.3%</td>
<td>9.4%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Rather good ($+1$)</td>
<td>50.0%</td>
<td>51.9%</td>
<td>50.0%</td>
<td>46.9%</td>
<td>48.6%</td>
</tr>
<tr>
<td>Very good ($+2$)</td>
<td>28.8%</td>
<td>33.7%</td>
<td>9.1%</td>
<td>28.1%</td>
<td>31.7%</td>
</tr>
<tr>
<td>$M$</td>
<td>0.97</td>
<td>1.13</td>
<td>0.55</td>
<td>0.81</td>
<td>1.01</td>
</tr>
<tr>
<td>$SD$</td>
<td>0.928</td>
<td>0.813</td>
<td>0.858</td>
<td>1.148</td>
<td>0.930</td>
</tr>
</tbody>
</table>

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**Fig. 3.** The system features according to the test drivers.
fault-free system found the aesthetics of the system better than did initially undecided drivers ($F(2,149) = 6.541, p < 0.05$ Post Hoc ($p < 0.10$)) and drivers with a faulty system ($F(1,149) = 3.626, p < 0.10$) respectively. The interaction showed that middle-aged and older drivers with an initially positive attitude rated the system more attractive than did initially negative drivers in the same age categories ($F(4,149) = 2.927, p < 0.05$), see Fig. 4.

The system was considered to be “effective”, “clear” and “informing” rather than “ineffective” ($M = 1.83, SD = 1.311, p < 0.05$), “unclear” ($M = 1.62, SD = 1.327, p < 0.05$) and “confusing” ($M = 1.56, SD = 1.397, p < 0.05$), see Fig. 3. Further analysis showed that older drivers and drivers with a fault-free system found the system more “effective” compared to younger drivers ($H(2) = 6.145, p < 0.05$, Post Hoc $p < 0.05$) and drivers with a faulty system ($U(n_1 = 52, n_2 = 111) = 2347.5, p < 0.05$) respectively. Women thought the system was more “clear” than men did ($U(n_1 = 54, n_2 = 107) = 2288.0, p < 0.05$) and private drivers thought the system was more “informing” than company car drivers did ($U(n_1 = 18, n_2 = 144) = 986.0, p < 0.10$).

In general the AAP was considered neither “comfortable” nor “uncomfortable” ($M = 0.12, SD = 1.455, p < 0.05$). However, analysis yielded statistically significant main effects of age, gender, driver type and system failure as well as interaction between gender and driver type. The younger drivers, females, company car drivers and drivers with a faulty system found the AAP more “uncomfortable” than middle-aged and older drivers ($F(2,154) = 4.388, p < 0.05$, Post Hoc $p < 0.05$), male drivers ($F(1,154) = 8.343, p < 0.05$), private car drivers ($F(1,154) = 4.643, p < 0.05$) and drivers without system problems ($F(1,154) = 10.096, p < 0.05$) respectively. The interaction showed that responses from women were more influenced by their driver type than responses from men were ($F(1,154) = 4.625, p < 0.05$), see Fig. 5.

Generally, the younger drivers, company car drivers and drivers with a faulty system found the system features less agreeable, while initially positive drivers found the system features more agreeable, see Table 3.

![Fig. 4. Estimated marginal means by ANOVA for the interaction between age and initial attitude on the scale “ugly”–“attractive”.](image-url)

![Fig. 5. Estimated marginal means by ANOVA for the interaction between gender and driver type on the scale “uncomfortable–comfortable”.](image-url)
Table 3
Differences in perception of the system features, main effects (p < 0.10)

<table>
<thead>
<tr>
<th>Age: Younger drivers</th>
<th>Gender: Women</th>
<th>Drive type: Company car drivers</th>
<th>Initial attitude: Positive drivers</th>
<th>System failure: Faulty system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less pleasant</td>
<td>More clear</td>
<td>Less important</td>
<td>More pleasant</td>
<td>Less good</td>
</tr>
<tr>
<td>More irritating</td>
<td>More uncomfortable</td>
<td>Less informing</td>
<td>More attractive</td>
<td>Less important</td>
</tr>
<tr>
<td>Less effective</td>
<td>More uncomfortable</td>
<td>More uncomfortable</td>
<td>Less pleasant</td>
<td>Less pleasant</td>
</tr>
<tr>
<td>More uncomfortable</td>
<td>More uncomfortable</td>
<td>More uncomfortable</td>
<td>Less attractive</td>
<td>Less soothing</td>
</tr>
</tbody>
</table>

4.3. Effects on the driver

The drivers in general thought their performance as car drivers was better when using the AAP compared to driving without the system (p < 0.05), see Table 4. The ANOVA analysis yielded statistically significant main effects of initial attitude and system failure, showing that initially positive drivers and drivers with a fault-free system thought their performance was better than that of initially negative drivers (F(2,159) = 3.329, p < 0.05) and drivers with a faulty system (F(1,159) = 3.520, p < 0.10) respectively, see Table 4.

The driving effort increased when using the AAP according to the drivers (M = 0.22, SD = 0.872, where −2 = “much less”, −1 = “somewhat less”, 0 = “unchanged”, +1 = “somewhat more”, +2 = “much more”, p < 0.05). Statistically significant main effects of age were found, indicating that younger drivers reported greater effort than older drivers did (F(2,160) = 2.849, p < 0.10).

The driving enjoyment decreased when using the AAP (M = -0.36, SD = 0.787, p < 0.05), see Fig. 6. Statistically significant main effects showed that initially positive drivers, drivers with a fault-free system, and drivers with a faulty system rated the driving enjoyment higher than initially negative drivers (F(2,143) = 10.635, p < 0.05, Post Hoc p < 0.05) and drivers with a faulty system (F(1,143) = 4.324, p < 0.05) respectively. Interaction effects showed that an initially negative attitude towards the system influenced the driving enjoyment more for women than for men (F(2,143) = 3.965, p < 0.05), see Fig. 7. Moreover, an initially positive attitude influenced the company car drivers’ enjoyment more than that of the private drivers’ (F(2,143) = 3.677, p < 0.05) and the older drivers’ enjoyment was in general more influenced by their initial attitude compared to younger drivers (F(4,143) = 3.083, p < 0.05), see Fig. 7.

The irritation increased slightly when using the AAP (M = 0.16, SD = 0.781, p < 0.05). The analysis showed the main effects of a system failure and the interaction effects between system failure and gender. Drivers with a faulty system were more irritated than drivers with a fault-free system (F(1,154) = 8.648, p < 0.05) and women were more affected by system failure than men (F(2,143) = 3.965, p < 0.05), see Fig. 8.

No general effect in stress level was found (M = 0.08, SD = 0.880, p = 0.246), but the analysis yielded statistically significant effects of initial attitude and system failure as well as interaction between gender and initial attitude and gender and system failure. Initially negative drivers and drivers with a faulty system reported
higher stress levels than initially positive drivers ($F(2,151) = 3.771, p < 0.05$, Post Hoc $p < 0.05$) initially unde-
cided drivers (Post Hoc $p < 0.10$) and drivers with a fault-free system ($F(1,151) = 5.564, p < 0.05$) respectively. The interactions effects showed that women’s stress levels were more influenced both by their initial attitude ($F(2,151) = 2.781, p < 0.10$) and by system failure ($F(1,151) = 4.045, p < 0.05$) than the stress levels of men were, see Fig. 9.

The drivers reported an increase in the feeling of being an obstacle ($M = 0.78, \text{SD} = 0.675, p < 0.05$). Women reported a larger increase than men ($F(1,159) = 3.926, p < 0.05$) and interactions indicated that company car drivers were more influenced by gender compared to private car drivers ($F(1,159) = 3.572, p < 0.10$), see Fig. 10.
Generally, the drivers with a faulty system found worse effects on the driver compared to drivers with a fault-free system, and drivers who were positive to the system before the trial found the effects on the drivers to be more positive compared to drivers who initially were negative, see Table 5.

4.4. Effects on driving outcome

The drivers had an impression of increased safety when using the AAP \( (M = 0.22, \ SD = 0.764, \ p < 0.05) \), see Fig. 11. The travel time was perceived as increasing when using the AAP \( (M = 0.23, \ SD = 0.513, \ p < 0.05) \) while no statistically significant change in fuel consumption was found \( (M = 0.04, \ SD = 0.817, \ p = 0.50) \). There were indications that drivers with a faulty system reported higher fuel consumption than drivers not having these problems \( (F(1,157) = 3.489, \ p < 0.10) \).

The risk of being fined for speeding decreased significantly according to the drivers \( (M = -1.34, \ SD = 0.708, \ p < 0.05) \), as did their travel speed \( (M = -1.02, \ SD = 0.597, \ p < 0.05) \). Drivers with a fault-free system found a larger reduction in the risk of being fined for speeding \( (U(n_1 = 51, \ n_2 = 110) = 3503, \ p < 0.05) \).
than drivers with a faulty system. The analysis of speed changes yielded statistically significant main
effects of gender and driver type. Further, there were interactions between gender and driver type. Men and
private drivers reported larger reductions in speed than women ($F(1,155) = 4.273, p < 0.05$) and company car
drivers respectively ($F(1,155) = 6.277, p < 0.05$). The interaction showed that the female drivers’ impression of
speed change was more influenced by their driver type compared to the impression of male drivers
($F(1,155) = 4.134, p < 0.05$), see Fig. 12.

Generally, the drivers with a faulty system thought the effects on the driving outcome were worse compared
to drivers with a fault-free system, see Table 6.

4.5. Keep and pay

Forty-four drivers (28.4%) wanted to keep the system after the trial was over. The Kruskal–Wallis test
showed statistically significant differences between age groups. Middle-aged drivers wanted to keep the
AAP to a larger extent (39.5%) than the younger drivers (13.0%) ($H(2) = 10.846, p < 0.05$, Post Hoc $p < 0.05$).

Thirty-two drivers were willing to pay an average of 841 SEK (~90€) to keep the system, see Table 7. The
analysis indicated that initially positive drivers were willing to pay more compared to initially undecided driv-
ers ($H(2) = 5.860, p < 0.10$, Post Hoc $p < 0.05$).

### Table 6

| Differences in perception of effects on driving outcome, main effects |
|-------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Age: Younger drivers    | Gender:         | Drive type:     | Initial attitude: | System failure: |
|                         | Women           | Company car drivers | Positive drivers | Faulty system   |
| –                      | Smaller speed change | Smaller speed change | –                | Higher fuel consumption |
|                        |                  |                  |                  | Larger risk of being fined for speeding |

Fig. 11. Reported effects on driving outcome.

![Fig. 11. Reported effects on driving outcome.](image)

Fig. 12. Estimated marginal means of speed change on 30 km/h roads by ANOVA for the interaction between gender and driver type.

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Forty-four drivers (28.4%) wanted to keep the system after the trial was over. The Kruskal–Wallis test
showed statistically significant differences between age groups. Middle-aged drivers wanted to keep the
AAP to a larger extent (39.5%) than the younger drivers (13.0%) ($H(2) = 10.846, p < 0.05$, Post Hoc $p < 0.05$).

Thirty-two drivers were willing to pay an average of 841 SEK (~90€) to keep the system, see Table 7. The
analysis indicated that initially positive drivers were willing to pay more compared to initially undecided driv-
ers ($H(2) = 5.860, p < 0.10$, Post Hoc $p < 0.05$).

### Table 6

| Differences in perception of effects on driving outcome, main effects |
|-------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Age: Younger drivers    | Gender:         | Drive type:     | Initial attitude: | System failure: |
|                         | Women           | Company car drivers | Positive drivers | Faulty system   |
| –                      | Smaller speed change | Smaller speed change | –                | Higher fuel consumption |
|                        |                  |                  |                  | Larger risk of being fined for speeding |
When estimating the market price, the drivers who gave a price (>0 SEK) stated that the system should cost on average 1604 SEK (≈180€) in a new car and 1393 SEK (≈155€) when retrofitting. Twenty-two percent of the drivers did not think that the AAP should increase the price of a new car and 19% thought that it should not cost more to be installed in an older car. Drivers with a fault-free system stated a higher market price for the system in a new car than drivers with a faulty system ($U(n_1 = 27, n_2 = 57) = 567.0, p < 0.05$).

4.6. Results sum-up

The evaluation of all responding drivers and the main and interaction effects of age, initial attitude, gender, driver type and system failure are summarized in Table 8.

5. Discussion

In this study the test drivers had the AAP system installed in their own cars and used the system regularly for between six months and one year. The drivers' evaluation of the system was therefore very realistic and well founded.

The study has shown that the concept of the AAP was rated positively while the willingness to keep and pay for the system was rather lower. The system was found to be more useful than satisfactory. High ratings such as “good” and “important” indicate a general need for a system like the AAP and high ratings such as “effective”, “clear” and “informing” pointed to the fact that the system could fill those needs. The system was reported to be only slightly “pleasant” and slightly “ugly” and neither “soothing” nor “comfortable”. While, using the AAP the drivers felt an increase in the “feeling of being an obstacle”, “effort” and “irritation” as well as a reduction in “enjoyment”. Notwithstanding, they also felt they were slightly better drivers when using the AAP. The largest effect on the driving outcome was a considerable reduction in the risk of getting speeding tickets. The drivers also felt a slight increase in their safety as well as travel time.

The responses from the drivers were influenced by their age, gender, initial attitude towards the system, driver type and whether they had experienced system failure. The results suggest that the most typical sceptical driver was a young, male, company car driver with an initially negative attitude and a faulty system. The most typical enthusiastic driver was an older, female, private driver with an initially positive attitude and a fault-free system. The main effects of age, gender, initial attitude and driver type show the importance of including different driver categories when evaluating driver support systems. Most main effects were found in connection with system failure, showing that problems with technology can influence driver evaluation of a system considerably. The interactions effects indicated that women were more influenced by their initial attitude, their driver type and system failure compared to men, and that company car drivers and older drivers were more influenced by their initial attitude than private car drivers and younger drivers respectively. These results correspond, but one should bear in mind that the interactions analysis could not be carried out for all items.

The results reflect the comprehension of Swedish drivers in a Swedish setting. Studies in other countries are necessary to determine whether drivers with other driving traditions and settings react differently.

It should be noted that that drivers’ evaluation of the system, and any reasons for it, do not necessarily reflect the reality as measured by objective data. Analysis of objective driving data and subjective driver evaluation has shown inconsistency between experiences and behaviour (Adell, 2007). Nevertheless, it must be acknowledged that the drivers’ subjective experiences are what influence their assessment of the system, and therefore also their willingness to have, buy and use the system.
Table 8
The average responses and the main and interaction effects of age, initial attitude, gender, driver type and system failure

<table>
<thead>
<tr>
<th></th>
<th>Average response (scale)</th>
<th>Main effects</th>
<th>Interactions</th>
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<tr>
<td></td>
<td></td>
<td>Age</td>
<td>Initial attitude</td>
<td>Gender</td>
<td>Driver type</td>
<td>System failure</td>
<td>Gender with Initial attitude</td>
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<td>The idea</td>
<td>(-2 to +2)</td>
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<tr>
<td></td>
<td>0.97**</td>
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<tr>
<td>System features</td>
<td>(-3 to +3)</td>
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<td>Good</td>
<td>0.94**</td>
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<tr>
<td>Important</td>
<td>1.26**</td>
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<tr>
<td>Pleasant</td>
<td>0.28**</td>
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<tr>
<td>Soothing</td>
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<tr>
<td>Attractive</td>
<td>-0.24**</td>
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<tr>
<td>Effective</td>
<td>1.83**</td>
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<tr>
<td>Clear</td>
<td>1.62**</td>
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<tr>
<td>Informing</td>
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<tr>
<td>Comfortable</td>
<td>0.12</td>
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<tr>
<td>Effects on the driver</td>
<td>(-2 to +2)</td>
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<td>Performance</td>
<td>0.27**</td>
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<tr>
<td>Effort</td>
<td>0.22**</td>
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<tr>
<td>Enjoyment</td>
<td>-0.36**</td>
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<td>Irritation</td>
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<td>Stress</td>
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<td>Feeling of being an obstacle</td>
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<td>Effects on driving</td>
<td>(-2 to +2)</td>
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<td>Travel time</td>
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<td>Speeding tickets</td>
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<td>Speed, 30 km/h</td>
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<td>Keep and Pay</td>
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<tr>
<td>Keep</td>
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<td>Pay to keep</td>
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<td>Market price as retrofit</td>
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</table>

n.a. = not applicable, the analysis was done by non-parametric statistics.

* The significance level refers to difference from 0 = “unchanged”.

* p < 0.10.

** p < 0.05.
The rating of driver support systems as “useful” has also been noted in other studies. Van der Laan, Heino, and de Waard (1997) reported positive usefulness ratings for a tutoring and enforcement system, an intelligent cruise control and a collision avoidance system, but both positive and negative satisfaction ratings. Nilsson (2003) found positive ratings for both usefulness and satisfaction for the ACC (Active Cruise Control) and the Driving Monitoring System. The willingness to pay for the AAP seems to be lower than for several other driver-assistance systems studied elsewhere. Thirty-eight percent and 29% of the test drivers were willing to pay to have the AAP installed in a new and an older car respectively. This should be compared to a willingness to pay of about 90% of the drivers for the Lateral Support System and the ACC, and between 60% and 75% for the Driver Monitoring System studied in the ADVISORS project (Nilsson, 2003). The amount of money the drivers were willing to pay is not easily comparable. In broad outlines, the willingness to pay for the AAP in a new car was somewhat less than for the Lateral Support System and the ACC (the willingness to pay was rather evenly distributed between the two price categories 101–200€ and 201–500€). The willingness to pay for retrofitting the AAP is comparable to the willingness to pay for Driver Monitoring System (median willingness to pay in the category of 101–200€) (Nilsson, 2003).

In this trial, the drivers’ general assessment of the system as an idea stands in contrast with the “close to action” statement about willingness to keep the system. This raises an important question of what acceptance is and how it can be measured. As Regan, Mitsopoulos, Haworth, and Young (2002, p. 9) stated: “While everyone seems to know what acceptability is, and all agree that acceptability is important, there is no consistency across studies as to what ‘acceptability’ is and how to measure it”. There have been some studies dealing with acceptance measurements (for example Van der Laan et al., 1997), but none have offered a satisfactory definition. As long as the meaning of “acceptance” is not defined, comparing the results of different studies is very hard. Further, the lack of definition increases the risk of unreliable assessments and/or biased due to the purpose of the study and/or the skill of designing surveys.

The low willingness to keep the system can be interpreted in two ways: (1) The negative experiences of the drivers (low satisfaction, increased emotional pressure and the perceived longer travel time) induce a lower willingness to keep the system, either by outweighing the positive aspects or by being below an acceptable threshold. (2) The positive experiences (high usefulness, increased performance as a driver, increased safety and reduced risk of getting speeding tickets) are not important to the driver, or not as important as the negative experiences. The positive ratings regarding the usefulness of the system do not necessarily mean that the drivers think the system is useful for them as individuals. If the driver thinks that his/her risk of being involved in an accident is practically zero, increased safety might not be enough to put up with the negative effects. The aggregated benefits of increased traffic safety by equipping cars with safety systems are not necessarily recognized by the individual driver, since the perception of traffic safety and risk is usually very vague (Summala, 1988). If personal benefits are not clear to the drivers, voluntary implementation has to rely on drivers being willing to act for a collective good.

The test drivers thought that the AAP system was useful but not satisfactory, and that it increased the emotional pressure on the driver, but that it had positive impacts on performance and safety. However, the largest perceived effect was a decrease in the risk of being fined for speeding.

The contrast between the drivers’ response to the concept of the AAP and the willingness to keep the system puts a clear focus on the importance of defining acceptance and developing a tool to ensure reliable assessment of acceptance and make inter-study comparisons possible.

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Regan, M. A., Mitsopoulos, E., Haworth, N., & Young, K. (2002). *Acceptability of in-vehicle intelligent transport systems to Victorian car drivers (Report No. 02/02)*. Melbourne, Australia: RACV.


