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Automated Feedback to Foster Safe Driving in Young Drivers: Phase 2

Intelligent Speed Adaptation (ISA) provides a promising approach to reduce speeding. A core principle of ISA is real-time feedback that lets drivers know when they are driving over the speed limit. The overall goal of the study was to provide insight into the effectiveness and acceptance by young drivers in the United States, of an ISA consisting of an Active Accelerator Pedal (AAP) system using haptic feedback (pedal resistance) to promote specific driving behavior. This project adapted the AAP from an earlier study that used haptic feedback to promote seat belt use. For this study, an upgraded AAP, speed mapping software, and a data logger were installed in two vehicles used for data collection. The AAP provided increased accelerator pedal resistance that required more effort to push the accelerator pedal whenever the driver exceeded the speed limit. It returned to normal pedal force when the vehicle speed dropped back to or below the speed limit. Researchers conducted two separate studies with young drivers (18-24 years old) to examine AAP effects on speeding, driver workload, and satisfaction with the system.

In the first study, researchers defined a driving route within the Kalamazoo/Portage area of Michigan consisting of six segments with varying speed limits, traffic conditions, and road types. Twenty-two pairs of participants (N=44) were matched by age and gender and then randomly assigned to either the experimental or the control group. Each pair of participants drove the route twice on a single day—morning and afternoon— with only one participant in each pair (experimental group) having the AAP pedal system active only in the afternoon drive. To control for time of day, day of week, weather, lighting, traffic conditions, and roadway conditions, each matched pair of participants drove on the same day at approximately the same time. The morning drive started after the height of rush hour (between 9:30 and 10 a.m.), and the afternoon drive ended well before rush hour to avoid the heaviest traffic which could impede the opportunity to speed.

The on-board data system periodically sampled vehicle speed during the data collection runs. Analysis of Variance (ANOVA) was used to test the statistical significance of differences among the mean scores of groups on factors of interest. For the measure *percent of speed measures 5+ mph over the speed limit,* the mixed ANOVA interaction effects for study drive time of day (morning/afternoon) and treatment group (control/experimental) were statistically significant ($p<.05$) for five of the six road segments. These effects are important because they indicate significant differences in speeding 5+ mph over the speed limit from the morning drive to the afternoon drive by study treatment group. Only Segment 3 showed no interaction effect, primarily because traffic controls and heavy traffic conditions constrained speeding for both study groups during both morning and afternoon drives.

Table 1 shows the average percentage of speed samples for treatment groups that were 5+ mph over the speed limit for each road segment during the morning drive. Table 2 shows the same measure for the afternoon drive **when the AAP system was active for drivers in the experimental group**. As can be seen in the tables, the experimental group showed decreased speeding on all segments in the afternoon compared to the morning while the control group actually showed increases in speeding on 5 of the 6 segments from morning to afternoon.

Table 1: Average Percent of Driving 5+ mph Over Speed Limit by Group and Road Segment in Morning

Road Segment (Speed Limit)	Experimental AAP Off		Control		p value
	Mean	SD	Mean	SD	
1 (25 mph)	18.83	11.37	13.87	8.59	.110
2 (35 mph)	8.99	10.99	17.57	13.40	**.025**
3 (45 mph)	0.12	0.47	1.90	3.90	**.040**
4 (70 mph)	10.45	13.85	22.45	19.66	**.024**
5 (55 mph)	4.18	4.56	7.68	5.18	**.022**
6 (30 mph)	8.70	4.75	17.70	8.31	**<.001**

Table 2: Average Percent of Driving 5+ mph Over Limit by Group and Road Segment in Afternoon

Road Segment (Speed Limit)	Experimental AAP Off		Control		
	Mean	SD	Mean	SD	p value
1 (25 mph)	6.11	6.94	22.60	8.84	**<.001**
2 (35 mph)	2.01	3.86	23.79	8.80	**<.001**
3 (45 mph)	0.02	0.10	1.71	2.39	**.002**
4 (70 mph)	2.39	10.00	31.60	21.53	**<.001**
5 (55 mph)	1.75	2.75	9.24	6.20	**<.001**
6 (30 mph)	3.30	3.30	19.52	10.88	**<.001**

Analysis of workload scores of mental demand, physical demand, temporal demand, performance, effort, and frustration level for each road segment also showed significant interaction effects. The results showed little difference between the control and experimental groups during the morning (baseline) drives when neither group was subject to pedal feedback. This lack of differences in workload ratings during the baseline drives suggests the cars performed in a similar fashion, and the random assignment of drivers to groups was successful. The control group (no AAP) showed reduced workload during their afternoon drives, likely reflecting greater familiarity with the routes and the vehicles. In contrast, the experimental group (AAP active) showed greatly increased workload during the afternoon drive on the initial road segments when they first experienced the pedal feedback. Their workload was slightly reduced on the later road segments as they became more familiar with the pedal feedback system, but workload levels on these later segments never dropped below the morning baseline levels. Overall, results of this first study showed the AAP pedal feedback system led to less speeding and increased driver workload when activated.

The second study involved giving an AAP-equipped vehicle to four participants to use for 15 days in place of their personal vehicles. The system was off during the first 5 days, activated during the second 5 days, and again turned off for the final 5 days. While the sample size of this second study was small, the results were encouraging with two of the four participants showing significantly reduced speeding 5+ mph over the limit when the pedal was active during Period 2 (the second 5 days) as shown in Table 3.

Table 3: Percent of Driving 5+ mph Over Speed Limit by Study Period

Participant	Period 1	Period 2	Period 3
1	9.39	*14.47*	7.46
2	7.28	*3.47*	9.90
3	15.89	*6.38*	*9.11*
4	4.88	4.42	5.28

Note: Values in italics represent statistically significant ($p<.05$) differences in speeding from baseline (Period 1) for that participant.

Analyses of the workload measures for the 4 participants showed increases in mental, physical, temporal, and effort demand when the AAP was active. Only one participant showed lower TLX performance scores during the AAP active period, and frustration results were mixed across participants. Taken together, these results suggest that the AAP did increase demand on the drivers when active, but had little impact on their ability to perform the driving task as a whole.

Across both studies, participants indicated support for the widespread use of the AAP if it saved them money (e.g., through lower insurance premiums). They liked the increased awareness of the speed limit they received from the AAP, but disliked being slower than prevailing traffic when the AAP was engaged. There was some increased mental and physical workload with the AAP and some increased driver frustration, but these increases were not extreme.

These two studies produced results not unlike those reported in the literature from Europe. Overall, the AAP system showed promise as a countermeasure for speeding by young drivers in the United States, but it tended to act more as a governor than as an agent for long-term behavioral change. There are, however, some potential issues to address in the widespread implementation of an AAP. Therefore, more research is needed to examine innovative alternatives for introducing an AAP.

How to Order

To order *Automated Feedback to Foster Safe Driving in Young Drivers: Phase 2* (52 pages), prepared by Dunlap and Associates, Inc., write to the Office of Behavioral Safety Research, NTI-130, NHTSA, 1200 New Jersey Avenue SE., Washington, DC 20590, fax 202-366-2766, or download from www.nhtsa.gov.

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