Commercial Drivers' Initial Attitudes toward an On-Board Monitoring System

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Several studies have shown the effectiveness of on-board monitoring for improving commercial driver safety but little has been done to examine truck drivers' attitudes toward such systems. The purpose of the current study is to examine these drivers' initial attitudes toward an on-board monitoring system (OBMS) as influenced by driver characteristics and driving experiences. Commercial drivers' attitudes and demographics were collected via a questionnaire distributed after a brief introduction of an OBMS. The results of a cluster analysis revealed three subgroups of commercial drivers who had negative, moderately positive, and extremely positive attitudes toward OBMS. Those with extremely positive attitudes, named the Fanatics cluster indicated that they would highly trust the system and felt they would adjust their driving based on system feedback. The cluster with more negative attitudes (named Opponents) showed a higher proportion of non-married drivers than married drivers and reported that the system would be an invasion of privacy. This study provides some insights on commercial drivers' attitudes toward feedback from technology and can help designers and researchers understand differences in drivers' willingness to accept and use feedback systems.

INTRODUCTION

Commercial drivers' risky behaviors such as improper lane keeping and following, distraction, and fatigue have been associated with a large number of fatal large truck crashes (Bunn, et al., 2005; FMCSA, 2010; Starnes, 2006). On-board monitoring systems (OBMSs), which measure various aspects of driver behavior and provides real-time feedback to drivers, have been effective in reducing these risky behaviors and promoting safer driving among truck drivers. For instance, truck drivers with a forward collision warning system have been shown to keep longer following distances than drivers without such a system (Bartlett, et al., 2005). Lane departure warning systems have also been proven effective in reducing lane departures, increasing turn signal use, and decreasing variations in lane deviations (Orban, et al., 2006).

A prerequisite for OBMS being effective in improving safety is that drivers appropriately use the system (i.e., act upon the feedback received from OBMS). Users' intentional and actual system use is highly correlated with their acceptance of the new technology (Davis, et al., 1989; Legris, et al., 2003). This suggests that the safety benefits of an OBMS depend on truck drivers' attitudes toward the system. Drivers are more willing to accept feedback if they perceive greater benefits and observe fewer concerns (Huang, et al., 2005). However, if drivers do not see any benefit in the system, they are likely to tamper with the system or even quit their job. Therefore, examining truck drivers' perceptions before, during, and after exposure to OBMS is essential to understanding its potential effectiveness.

Surveys showed that the majority of commercial drivers, in spite of their experiences with OBMS, had somewhat positive attitudes toward OBMS and feedback (Huang, et al., 2005). Face-to-face interviews with drivers who have never used such a system showed that they were willing to try such a system and expected it would improve their driving safety (Houser , et al., 2007). Other studies with experienced OBMS users showed that drivers believed that being exposed to feedback would make them safer drivers (Hickman & Hanowski, 2010; Orban, et al., 2006).

A field operational test on forward collision warnings showed that drivers believed that using the system would be beneficial in avoiding rear-end crashes and more than 50% of the participating drivers reported that they had adjusted their driving to the system (Battelle, 2004). However, a separate field operational test on lane departure warnings showed that truck drivers had mixed responses to the usefulness of feedback, with some drivers indicating that using the system decreased overall driving satisfaction and the system did not really help with their job as a truck driver (Orban, et al., 2006).

Understanding the types of truck drivers who have negative perceptions toward feedback may assist companies in overcoming negative driver opinions when implementing an OBMS. However, no study has examined the differences that may exist among truck drivers who have positive or negative attitudes toward feedback. Some of the potential differences may be due to the diversity in driving experiences, driving styles, demographics, and driver personalities. The purpose of the current study is to explore these factors using a survey that examine the commercial drivers' pre-exposure acceptance toward an OBMS.

METHODS

Participants

Participants were recruited from a motor carrier terminal site that will be installing OBMS in all its trucks. Approximately 100 drivers were employed at this terminal site. Among these drivers, 42 agreed to participate in the study and 37 of them completed the questionnaire (37% response rate). This study was approved by the University of Washington's Institutional Review Board [IRB No. 39876].

Summary of Questionnaire

The questionnaires used in this study examined commercial drivers' initial opinions and expectations of the OBMS-a system they will be using a few months after this initial meeting. This specific OBMS provides a number of real-time visual and auditory warnings including forward collision warnings, lane departure warnings, and other driver performance warnings (e.g., long glances away from road, hard braking) (Boyle & Peng, 2010).

A 7-point Likert scale ("strongly disagree", "disagree", "slightly disagree", "neutral", "slightly agree", "agree", and "strongly agree") was used to measure respondents' agreements with each survey item. The questions included expected usefulness (e.g., "I think using the OBMS will make me a safer driver", "I think using the OBMS will reduce sleepiness") and ease of use (e.g., "I think the OBMS will be easy to use", "I think the OBMS will be easy to learn") for the system as a whole and for each major alert the drivers may encounter. The survey also asked about drivers' attitudes on whether they would trust, depend, and use the system if it was installed in their trucks. Privacy concerns related to the use of the system and sharing performance data with safety supervisors for coaching purposes was also examined. There were also questions at the end of the survey related to driver demographics (e.g., gender, age, and marital status), driving experience, and driving records. The questionnaire was designed to be completed within 25 minutes.

Procedure

Information sessions on the OBMS and the questionnaire study were held for all drivers at their terminal site. A brief introduction on the OBMS functions and benefits was provided during each session, followed by an explanation of the survey study purposes and procedures. Drivers' participation in the questionnaire study was completely voluntary. At the end of each information session, drivers who were willing to participate signed the informed consent form (ICF). Although it would be ideal to gather the responses immediately after the information session, it was not feasible due to the varying driver schedules. Therefore, those drivers who signed the ICF were given a copy of the questionnaire along with a self-addressed stamped envelope to return the completed survey to the research team. A reminder letter and a replacement questionnaire were sent to the drivers who consented to the study but did not return the questionnaire within five weeks of the attended information session. Each participant was compensated $10 for completion of the questionnaire.

Data Analysis

Cluster analysis is commonly used for identifying homogeneous groups of population based on given attributes (Aldenderfer & Blashfield, 1984). For instance, previous studies have used cluster analysis to examine demographic differences among truck drivers regarding their attitudes toward the environment and energy (Schweitzer, et al., 2008) and personality differences in younger drivers regarding risk taking and crash involvements (Pal, 2001).

A cluster analysis (conducted using R Statistics 2.12.1) was used in the current study to classify commercial drivers by their overall attitudes toward the OBMS. The analysis was performed on 37 drivers who had completed the questionnaire. Five variables were used for clustering: one question related to drivers' privacy concerns and four questions related to acceptance attributes (Table 1). Privacy was taken into consideration because of previous concerns on the use of technology to record driver's locations and movements (Huang, et al., 2005). The four acceptance attributes include questionnaire items on perceived usefulness, perceived ease of use, trust, and intention to use (Davis, et al., 1989; Ghazizadeh, et al., 2011).

Table 1: Survey questions used in the cluster analysis

Aspect of Attitude	Survey Question
Perceived Usefulness	Q1: I think using the OBMS will make me a safer driver
Perceived Ease of Use	Q2: I think the OBMS will be easy to use
Trust	Q3: I will trust the information I receive from the OBMS
Intention to Use	Q4: If I have the OBMS, I would adjust my driving to its information
Privacy Concerns	Q5: I think being monitored by the OBMS will be an invasion of my privacy

The five variables were not highly correlated ($r < .90$), so strong collinearity was not a concern for the analysis (Mooi & Sarstedt, 2011). In addition, the sample size was considered sufficient with five clustering variables ($n \geq 2^m$,where m = number of clustering variables, n = sample size) (Formann, 1984). A hierarchical clustering method with complete linkage and Euclidean distance measure was used, as it is one of the most suitable methods to analyze ordinal data (Mooi & Sarstedt, 2011). A fusion coefficient plot (or plot of the number of clusters against the distance at which clusters are combined) were used to determine the final clustering solution (Aldenderfer & Blashfield, 1984). The number of clusters was determined at the distinctive breaking point (elbow) (Aldenderfer & Blashfield, 1984; Mooi & Sarstedt, 2011). Kruskal-Wallis Rank Sum tests were conducted to examine between-cluster differences on questionnaire responses. Fisher's exact tests and ANOVA were performed to examine the demographic differences among clusters.

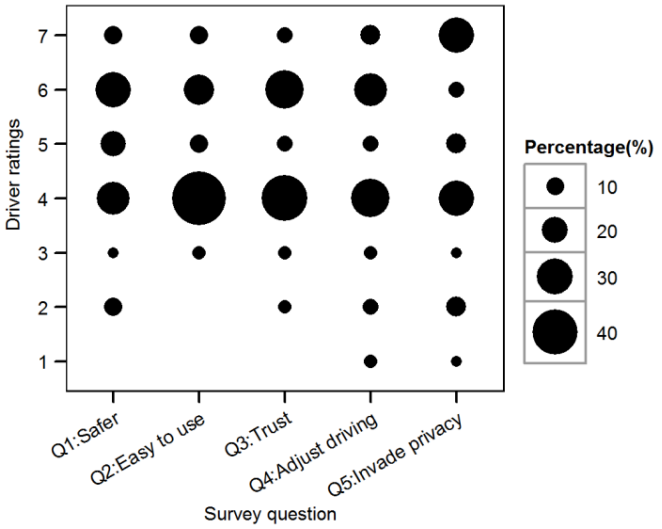
RESULTS

All survey respondents were male, with a mean age of 50.6 years old (SD = 7.6 yrs). On average, these drivers had been driving commercially for 21.7 yrs (SD = 9.5 yrs), and working in the trucking company where the study data was collected for 6.1 yrs (SD = 5.8 yrs). Among the 37 drivers, 28 were married, 16 had at least some college experience, 12 had

at least one moving violation in the last 3 years, and 7 drivers had at least one crash in the last 3 years.

Drivers' responses to the questionnaire appeared to be very different and bimodally distributed, especially on the trust and privacy concern questions (Figure 1). This indicates that different subgroups of drivers do exist and cluster analysis would be useful to identify them.

In general, drivers' attitudes toward OBMS were positive. Specifically, 60% of respondents at least somewhat agreed that using OBMS would make them safer drivers. Only 5% of drivers thought OBMS might be difficult to use. Approximately half of the drivers indicated that they would trust OBMS and adjust their driving based on OBMS information if they had the system. However, only 20% of respondents were not concerned with privacy issues related to the use of OBMS.



Note: 1=Strongly disagree, 7=Strongly agree, 4=Neutral

Figure 1: Respondents' general attitudes toward OBMS

Examining drivers' responses by driver demographics revealed that truck drivers who were married were less concerned with privacy issues. Specifically, only 32% of married drivers somewhat agreed that sharing driving data with safety supervisors would be an invasion of privacy, compared to 78% for unmarried drivers (Fisher's exact *p*-value = .02, OR = .14, 95% CI = [.01, .95]). Drivers who had moving violations or crash records in the last three years were willing to at least somewhat trust the OBMS when compared to drivers with clean records (Fisher's exact *p*-value = .02, OR = 5.6, 95% CI = [1.14, 33.5]). Further, 75% of drivers with moving violations at least slightly agreed on the usefulness of OBMS on highway/freeway, while only 41% of drivers with clean records believed in the usefulness of OBMS (Fisher's exact *p*-value = .03, OR = 6.8, 95% CI = [1.07, 78.4]).

Cluster Analysis Results

Observations of the fusion coefficient plot suggested a three-cluster solution (see Fig. 2 for the cluster dendogram representation). The three clusters were labeled based on the characteristics of drivers within each group as "Opponents" (8 drivers), "Proponents" (23 drivers), and "Fanatics" (6 drivers).

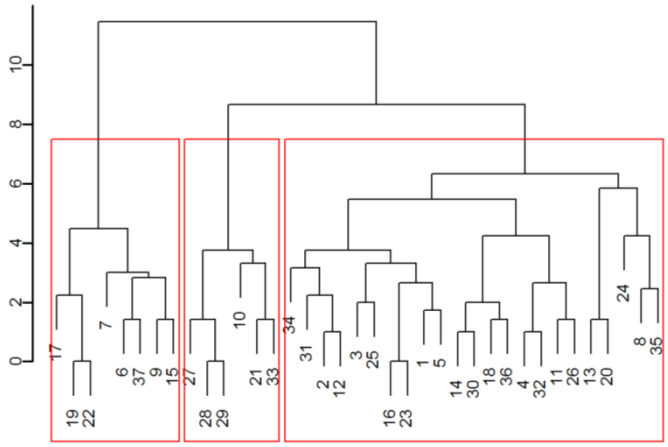


Figure 2: Cluster dendrogram with a three-cluster solution

Figure 3 shows the distributions of each cluster's responses to the five survey items used for clustering. The Opponents group had fairly negative or neutral responses to all survey questions. They did not believe that OBMS would make them safer drivers nor were they willing to adjust their driving based on the information received from OBMS. This group of drivers also had major concerns with invasion of privacy. However, they appeared to be undecided on whether the system would be easy to use or trustable.

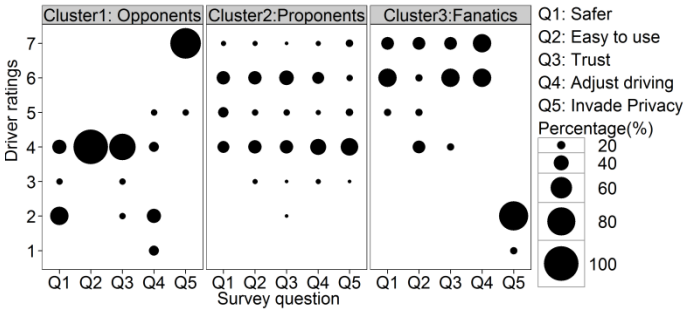


Figure 3: Attitudes toward OBMS by clusters

The Proponents group included the majority of respondents and had moderately positive responses to many survey questions. To some degree, these drivers believed that the system would make them safer. About half of the drivers in this group were somewhat willing to adjust their driving based on the system and believed that OBMS would be relatively easy to use and trustable. This group of drivers was also less concerned with privacy issues when compared to the Opponents group.

The Fanatics group had the highest positive attitudes toward the OBMS with strong positive agreement on system usefulness. They were extremely willing to adjust their behaviors based on the system and were not worried that the system would invade their privacy. Additionally, this group of drivers expected OBMS to reduce sleepiness (median ="slightly agree"). They also indicated that they would strongly trust and depend (median = "agree") on OBMS.

Kruskal-Wallis tests (Table 2) suggested that the three groups of drivers were significantly different on all five attributes used for the cluster analysis.

Table 2: Response medians by cluster

Question	Opponents	Proponents	Fanatics	H(df=2)
Safer	2.5	5	6	18.8**
Easy to use	4	5	5.5	6.4*
Trust	4	5	6	11.7**
Adjust driving	2	4	6.5	17.2**
Invade privacy	7	4	2	22.8**

*Note: **p < .01, *p < .05; 1=Strongly disagree, 4=Neutral, 7=Strongly agree,*

However, the three clusters were not significantly different on their responses to whether OBMS would make it easier to drive, be annoying, and make them more comfortable doing other things while driving. Specifically, the opponents had negative responses (median = "disagree", "slightly agree", and "disagree", respectively) to these three questions whereas the proponents and fanatics had neutral responses.

Table 3 shows driver demographics and driving experiences within each cluster. All three groups of drivers appeared to have similar age, years of driving with commercial driver's license, and years working at their trucking company (one-way ANOVA *p*-value > .05). Fisher's exact tests did not reveal any significant differences in drivers' marital status, driving records and educational levels. However, the proportion of unmarried drivers was the highest in the Opponents group (37.5%) and everyone in the Fanatics group was married.

Table 3: Driver demographics and driving experiences within clusters

	Opponents (n=8)	Proponents (n=23)	Fanatics (n=6)
Mean (and SD) of			
Age (in yrs)	50.4 (8.4)	51.4 (7.8)	47.8 (6.4)
Yrs with CDL	20.4 (11.1)	22.2 (10.2)	21.8 (4.2)
Yrs at company	5.9 (6.1)	5.9 (5.9)	7.4 (6.1)
Percent (and n) of cluster for:			
Marital status:			
Married	62.5% (5)	73.9% (17)	100.0% (6)
Unmarried	37.5% (3)	26.1% (6)	0% (0)
Driving records:			
Violation or crash	25.0% (2)	52.2% (12)	16.7% (1)
Clean	75.0% (6)	47.8% (11)	83.3% (5)
Education			
At least some college	37.5% (3)	52.2% (12)	16.7% (1)
High school or less	62.5% (5)	48.8% (11)	83.3% (5)

Opponents and Fanatics had the largest proportion of drivers with clean records. There was a fairly even split (52%/48%) for those with violations and clean records in the Proponent group. Similar observations were found for the drivers' educational levels within each cluster. The Proponents group also had the largest proportion of drivers with some college education.

DISCUSSION

This study identified three subgroups of commercial drivers with significantly different pre-exposure attitudes toward OBMS. More than half of the drivers in this study had somewhat positive attitudes toward OBMS. This is consistent with previous studies that found the majority of drivers believed feedback from technology would have safety benefits (Battelle, 2004; Houser , et al., 2007). A small number of drivers were placed in a group called Fanatics, as they strongly believed in the safety benefits and reliability of OBMS. Although this group of drivers was very willing to adjust their driving behaviors based on feedback, they may also overtrust the system, which can lead to misuse (Lee & See, 2004). Therefore, it is important to ensure that these drivers have a clear understanding of the limitations of OBMS so that trust is appropriately calibrated to the system properties.

About 20% of drivers were classified as Opponents as they viewed OBMS negatively and were extremely concerned about invasion of privacy. Therefore, companies that plan to deploy OBMS need to work on building positive attitudes toward OBMS by mitigating privacy concerns. They need to highlight the value of OBMS in reducing crashes and violations, which directly benefits the drivers as well as their families. The managers also need to reassure drivers that the driving performance data recorded by OBMS will not be used as a means of monitoring their every move, but rather can be useful in improving their driving skills as well as supporting their rights in a legal situation.

Another goal of the study was to identify whether initial attitudes toward OBMS could be associated with driver characteristics and experiences. There were more married drivers than unmarried drivers in our study population. However, a greater proportion of married drivers were observed in the Proponents and Fanatics group. There were also a greater proportion of drivers with clean driving records in the Opponents and Fanatics group. However, the chi-square test of proportions did not reveal any significant differences, but this may relate more to the small sample size.

The response rate for this study was lower than previous survey studies on truck drivers (Huang, et al., 2005; Schweitzer, et al., 2008) but this may be due to differences in the study goals: the questionnaire was used to assess a system that will include videos of the drivers. Given that participation was voluntary, there is a self-selection bias toward those drivers that have strong opinions on the use of the system. It is important to note that this questionnaire is the first of several questionnaires to be administered as part of a longitudinal study examining the usefulness of OBMS. Drivers' attitudes toward OBMS may change over time and after actual exposure to the system. Therefore, future studies will examine how pre-exposure perceptions may influence attitudes and driving performance after drivers' actual use of OBMS. Future studies will examine additional factors that may impact truck drivers' attitudes toward OBMS such as interactions with other technology. There may also be other underlying reasons why drivers with different social and cultural backgrounds may be more or less accepting of such technology. These are

important considerations for future studies and can guide the design and use of future OBMS devices.

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