

# Experiences of Dodge and Jeep Owners with Collision Avoidance and Related Technologies

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## ABSTRACT

**Objective:** Crash avoidance technologies have the potential to prevent or mitigate many crashes, but their effectiveness depends on drivers' acceptance and proper use. Owners of 2011 Dodge Charger, Dodge Durango, and Jeep Grand Cherokee vehicles were interviewed about their experiences with their vehicles' technologies.

**Methods:** Interviews were conducted in April 2013 with 215 owners of Dodge and Jeep vehicles with Adaptive Cruise Control and Forward Collision Warning, and an additional 215 owners with Blind Spot Monitoring and Rear Cross Path Detection.

**Results:** Most owners said they always keep each collision avoidance technology turned on, and more than 90 percent of owners with each system would want the technology again on their next vehicle. The majority believed the systems had helped prevent a collision, ranging from 54 percent of drivers with Forward Collision Warning to more than three-quarters with Blind Spot Monitoring and Rear Cross Path Detection. Some owners reported behavioral changes with the systems, but over-reliance on them is not prevalent. Reported use of the Dodge and Jeep systems varied by the age and gender of the driver and duration of vehicle ownership to a greater degree than in previous surveys of luxury Volvo and Infiniti vehicles with collision avoidance technologies. Most notably, drivers aged 40 and younger were most likely to report that Forward Collision Warning had alerted them multiple times and believe it had prevented a collision, and that they follow the vehicle ahead less closely with Adaptive Cruise Control. Reports of waiting for the alert from Forward Collision Warning before braking were infrequent but increased with duration of ownership. However, these reports could reflect misunderstanding of the system with Adaptive Cruise Control, which alerts drivers when braking is necessary but a crash is not imminent.

**Conclusions:** Consistent with previous surveys of luxury vehicle owners with collision avoidance technologies, acceptance and use remains high among owners of more mainstream vehicles. Varying experiences with the technologies reported by driver age and gender suggest that safety benefits are not uniform for all drivers, and differing benefits may become increasingly apparent as collision avoidance technologies become available to a more heterogeneous population of drivers. The potential for over-reliance on the technologies should continue to be monitored, especially as drivers gain more experience with them.

**Keywords:** Crash avoidance technology; Driver behavior **Research Topics:** Crash avoidance technologies: General

#### INTRODUCTION

Collision avoidance technologies that assist drivers with warnings or automatic braking when a crash is imminent have great potential to reduce traffic injuries and fatalities. Jermakian (2011) estimated that forward collision warning systems, which alert drivers to potential collisions with another vehicle or object in front of their vehicle, could prevent up to 20 percent of all police-reported crashes annually. Side-view assist systems, which alert drivers to other vehicles in their side blind zones when changing lanes, could potentially mitigate up to 7 percent of all police-reported crashes per year, and up to 24 percent of lane-change crashes. Some technologies help drivers with parking or provide other conveniences. Rear cross-traffic alert systems aid drivers while they are backing out of driveways or parking spaces with traffic entering the vehicle's path from the side. Adaptive cruise control keeps the vehicle at a preset speed when the road is clear, and slows down to keep a safe gap behind other vehicles when traffic is present.

Recent evidence from insurance claims data suggests that some collision avoidance technologies, such as forward collision warning systems, are preventing crashes. The Highway Loss Data Institute (2011, 2012a, 2012b) analyzed rates per insured vehicle year of property damage liability claims for Acura, Mercedes-Benz, and Volvo vehicles with forward collision warning systems compared with the same model vehicles without the optional systems. Some of the Mercedes-Benz and Volvo vehicles and all of the Acura vehicles were equipped with systems that also apply automatic emergency braking if the driver does not respond to the warning in enough time to prevent a crash; automatic braking, but not forward collision warning alone, was bundled with lane departure warning on Volvo vehicles. The rates of property damage liability claims, which cover damage to the other vehicles and property hit by an at-fault driver, were significantly lower for Acura and Mercedes-Benz models equipped with the technologies than for the same models without. Claim rates for Volvo vehicles also were lower for models with forward collision warning than for the same models without, but not significantly so. The forward collision warning than for the same models with automatic braking appeared to prevent crash claims to a greater extent than the systems of models that only provided a warning.

The real-world effects of advanced vehicle technologies depend on how they are used. If systems are turned off, for instance, they cannot reach their full potential in preventing crashes. How drivers

respond to warnings and adjust their regular driving behaviors with new systems can also affect safety. To date, much of what is known about how drivers use and accept collision avoidance systems on their vehicles is drawn from owners of luxury vehicles, which are generally the first to have new technologies. Surveys of owners of luxury Volvo and of Toyota vehicles with forward collision warning systems with autonomous braking found that nearly 9 in 10 owners always kept the system on, and 90 percent or more would want the system on their next vehicle (Braitman et al. 2010; Eichelberger & McCartt 2014a, 2014b). Few drivers reported negative behavioral changes with the system, such as waiting for a warning before slowing when approaching another vehicle. Among Volvo drivers with side-view assist, 82 percent always drove with the system turned on, and 95 percent would want the system again (Braitman et al. 2010). Nearly three-quarters reported receiving false or unnecessary warnings. Volvo drivers most often cited malfunctions in poor weather as the reason they shut off the system or received unnecessary alerts.

It is possible that initial information on the use of collision avoidance technologies from owners of luxury vehicles and other early adopters is not representative of how systems will be used by the general population of drivers. Therefore, it is important to assess experiences with these systems by owners of a variety of vehicle types as the technologies proliferate through the vehicle fleet. The current study surveyed owners of non-luxury Dodge and Jeep vehicles on their use of four technologies: adaptive cruise control, forward collision warning without automatic braking, side-view assist, and rear cross-traffic alert. In addition to collecting information on system use by owners of non-luxury vehicles, this study is the first to assess how owners of any vehicle type use and accept a forward collision warning system that does not brake autonomously and a rear cross-traffic alert system.

## **METHODS**

### **System Descriptions**

Owners of Dodge Charger, Dodge Durango, and Jeep Grand Cherokee vehicles with some combination of the following select technologies were included in the study: Adaptive Cruise Control, Forward Collision Warning, Blind Spot Monitoring, and Rear Cross Path Detection. The technologies, offered as optional equipment, are described below.

Adaptive Cruise Control helps drivers maintain a set speed and a preset following distance to other vehicles. Drivers set a cruising speed and following distance, and the system maintains the set

speed when it does not detect another vehicle ahead. The following distance to other vehicles can be adjusted to long, which is the default setting and results in a larger gap to the vehicle ahead; medium; or short. The system automatically applies limited braking or speeds up to the set speed to maintain the preset distance when its radar sensor detects a vehicle ahead. If the system's maximum braking level is not sufficient to maintain the set distance, it emits a proximity warning, where a chime sounds, the word "BRAKE" flashes in a display in the instrument panel, and the system continues to brake. Adaptive Cruise Control can operate at speeds above 20 mph. The system is off when the vehicle is started, and can be turned on and off while driving with a button located to the right of the steering wheel.

Forward Collision Warning detects potential collisions with vehicles ahead, using radar-based sensors, and alerts drivers with a chime and a message that flashes "BRAKE" in the instrument panel display. For the Dodge Durango and Jeep Grand Cherokee, the images accompanying the "BRAKE" message and the chime differ from the Adaptive Cruise Control proximity warning. For the Dodge Charger, the warnings from the two systems look and sound the same. Forward Collision Warning can be set to the default far setting that gives an earlier warning, the near setting that gives a later warning, or off. The system retains the latest setting after the vehicle is turned off until it is changed by the driver. The minimum speed at which Forward Collision Warning is operational is 10 mph.

Blind Spot Monitoring, a side-view assist system, uses radar-based sensors located in the rear bumper fascia to detect other vehicles in the driver's side blind spots. The system works at speeds of approximately 6 mph and above. When the vehicle is traveling forward and Blind Spot Monitoring detects another vehicle entering the blind spot, a warning light illuminates in the side mirror. The system can be set to lights/chime mode, where the warning light is accompanied by a chime if the turn signal is activated; lights only mode, where there is no chime; and off. Lights/chime mode was the default setting for most drivers, and lights only mode was the default for the remainder. Blind Spot Monitoring retains the latest setting after the vehicle is turned off until it is changed by the driver.

Rear Cross Path Detection is intended to help drivers backing out of parking spaces when their view of oncoming cross traffic may be blocked. The system alerts drivers that a vehicle moving toward the side of their vehicle is entering their blind spot. It uses the same sensors and alerts as Blind Spot Monitoring, and the systems turn on and off together. Rear Cross Path Detection always illuminates the

warning light in the appropriate side mirror and sounds a chime when another vehicle is detected, regardless of the Blind Spot Monitoring mode. The system detects other vehicles that are traveling at speeds between 1-2 and 10 mph.

## Questionnaires

Two separate pen-and-paper mail questionnaires were prepared. Questions about Forward Collision Warning and Adaptive Cruise Control were included in one survey, and questions about Blind Spot Monitoring and Rear Cross Path Detection were included in the other. All four technologies are packaged together in the Jeep Grand Cherokee. On the Dodge Charger and Durango, Adaptive Cruise Control and Forward Collision Warning are packaged together, and Blind Spot Monitoring and Rear Cross Path Detection are packaged together. All Charger and Durango owners surveyed about the Blind Spot Monitoring and Rear Cross Path Detection also had the optional package with Adaptive Cruise Control and Forward Collision Warning, but owners surveyed about Adaptive Cruise Control and Forward Collision Warning, but owners surveyed about Adaptive Cruise Control and Forward Collision Warning, but owners surveyed about Adaptive Cruise Control and Forward Collision Warning did not necessarily have the other technologies. All vehicles with Blind Spot Monitoring and Rear Cross Path Detection, and some with Adaptive Cruise Control and Forward Collision Warning, had ParkSense, a rear parking sensor system, and ParkView, a backup camera. ParkSense informs drivers of the distance to stationary objects directly behind the vehicle using a chime and a visual alert in the information center. The questionnaires did not include items about ParkSense or ParkView.

Survey recipients were instructed to give the questionnaire to the primary or a frequent driver of their Dodge or Jeep, and recipients who no longer owned their Dodge or Jeep, or who were unsure if their vehicle was equipped with the collision avoidance technologies, were asked not to return the questionnaire.

#### **Survey Participants**

A list of names and addresses of owners who had purchased model year 2011 Dodge Charger, Dodge Durango, and Jeep Grand Cherokee vehicles with Adaptive Cruise Control, Forward Collision Warning, Blind Spot Monitoring, and/or Rear Cross Path Detection was obtained from a confidential industry source. Questionnaires on Adaptive Cruise Control and Forward Collision Warning were mailed to 1,200 randomly selected owners with the technologies, and questionnaires on Blind Spot Monitoring

with Rear Cross Path Detection were mailed to 1,200 randomly selected owners with those technologies. Respondents were restricted to owners for whom addresses were known and who purchased their vehicle in the United States. Surveys were mailed in April 2013 and included a cover letter from the Insurance Institute for Highway Safety explaining the purpose of the research and postage-paid envelopes for returning completed questionnaires. Reminder postcards were sent to owners 1 week after the initial mailing. This study was approved by the Westat Institutional Review Board.

For each questionnaire, fully or partially completed questionnaires were returned by 215 owners (18%). One respondent to the survey on Adaptive Cruise Control and Forward Collision Warning and four respondents to the survey on Blind Spot Monitoring with Rear Cross Path Detection reported they no longer owned their vehicles, and one respondent to each survey said they did not know if their vehicle was equipped with the survey's technologies. Responses from these drivers were not considered further.

#### Analyses

Chi-square analysis was used to examine relationships between experiences with the system and characteristics such as driver age and gender and the duration of vehicle ownership. The Mantel-Haenszel chi-square statistic was used to test the statistical significance of linear trends involving driver age, and the Pearson chi-square statistic was used in other analyses.

#### RESULTS

The questionnaires described the features of the different systems. Respondents were then asked about their use of the systems, experiences receiving alerts, behavioral responses to the technologies and opinions about them, general driving habits, and demographics. Sample characteristics of the respondents are summarized in Table 1. Characteristics of respondents to the two surveys were remarkably similar. Slightly more than half (56%) were male. Twelve percent were aged 40 and younger, 53 percent were aged 41-60, and 33 percent were aged 61 and older. About half owned their vehicles for 2 years or longer.

More than 80 percent of the drivers surveyed about Adaptive Cruise Control and Forward Collision Warning reported that all or most (29%) or some (53%) of their trips in a typical week involved driving in slow-moving, stop-and-go traffic. Of drivers surveyed about Blind Spot Monitoring and Rear

Cross Path Detection, most (76%) back out of a parking space or driveway at least once a day, and the remainder do so a few times a week (21%) or rarely or never (1%).

#### Adaptive Cruise Control

**Use of system:** Of the 213 owners surveyed about Adaptive Cruise Control, 92 percent said they had used it at least once. More than half (54%) always used it on freeways, expressways, or other high-speed roads with few or no traffic signals, but few (8%) always used it on lower-speed roads with traffic signals or stop signs (Table 2). Most drivers (92%) who had used the system were aware of the settings for the following distance (short, medium, and long, the default setting), and 74 percent had adjusted the settings. The settings drivers typically used appear in Table 2.

**Behavioral responses to system:** Owners who had used Adaptive Cruise Control were asked how closely they followed the vehicle in front when using the system compared with when they were not using it. Four percent reported they followed more closely when using the system, 36 percent followed less closely, and 58 percent followed at the same distance. When asked a similar question about looking away from the road when using the system, a small percentage said they looked away from the road more (2%) or less often (4%) when using the system than when not using it.

Owners who had used the system were asked if they had received a proximity warning alerting them that the system's maximum braking level is not sufficient to maintain the set following distance to the vehicle ahead. Seventy-six percent reported they had received a proximity warning. Of the 148 owners who received a proximity warning, 84 percent indicated they braked in response to their most recent warning, 11 percent did not brake, and 4 percent did not know or respond to the question.

#### **Forward Collision Warning**

**Use of system:** Of the 213 owners who responded to questions on Forward Collision Warning, 84 percent always kept the system on (Table 3). Owners most often turned the system off because they did not need it on some types of roads (11 owners) or received alerts when not at risk of crashing (6 owners). The 212 owners who had experience with the active system answered the remaining questions. Owners were asked if they were aware that Forward Collision Warning had two settings for the distance

to the vehicle ahead. Forty percent were aware of these settings, and 13 percent had adjusted them. The settings drivers typically used are listed in Table 3.

**Experiences with alerts:** Most owners said the system had warned them of an impending crash with another vehicle more than once (83%) or once (6%), and 5 percent indicated they had been warned but not how often. More than half (54%) of owners thought the system had helped prevent a collision. The 199 drivers (94%) who had been alerted of an impending crash were asked about the timing of their most recent warning. Three-quarters said it had come at the right time, and fewer said it came too early (12%) or late (5%). No owners reported they had collided into the back of another vehicle while driving their Dodge or Jeep.

When asked how often the system fails to activate when it is on and they believe they are at risk of colliding with the vehicle in front of them, 12 percent of owners said it failed very often or sometimes (1%) or rarely (11%), and 55 percent said it had never failed. About a third (31%) did not know.

A larger number (61%) of owners reported that the system warned them when they believe they are not at risk of colliding with the vehicle in front of them very often (4%), sometimes (24%), rarely (31%), or at an unknown frequency (3%). Thirty percent never experienced warnings they believed did not indicate risk of crashing. The 130 owners who reported receiving alerts when they did not believe they were at risk of crashing were asked in what situations this occurred and could provide multiple responses. They were reported to have occurred most often when the vehicle in front slowed to turn (49%), stationary roadside objects such as guardrails or parked cars were ahead (42%), driving on curvy or winding roads (38%), and turning (23%).

**Opinions of alerts:** Drivers who had experienced warnings were asked whether they agreed or disagreed with several statements about them. Of the 199 owners who had been alerted, 94 percent agreed the chime was useful, 12 percent agreed it was annoying, 2 percent agreed it was too loud, and 6 percent agreed it was too quiet. Seventy-eight percent of owners who had been warned said they had seen the flashing warning message that accompanies the chime. Regarding the visible warning, 80 percent of owners who had seen it agreed it was useful, 6 percent agreed it was annoying, 8 percent agreed it was distracting, and 73 percent agreed it was easy to see.

**Behavioral responses to system:** Owners were asked how often they waited for an alert before slowing when approaching another vehicle. Forty percent said they did this very often (5%), sometimes (9%), or rarely (25%).

## Blind Spot Monitoring and Rear Cross Path Detection

**Use of systems:** Blind Spot Monitoring and Rear Cross Path Detection turn on and off together. Of the 210 drivers who answered questions on these systems, 95 percent reported they always drove with them turned on and all had used the systems at some point (Table 4).

Eighty percent of owners said they always looked at the Blind Spot Monitoring warning light in the side mirror when changing lanes (Table 4). Drivers were asked if they were aware of the Blind Spot Monitoring settings that control if a chime accompanies the warning light. Most owners (74%) were aware of these settings, but only 10 percent ever changed them.

The settings owners typically used appear in Table 4. Two-thirds of owners typically used the lights/chime mode, 20 percent typically used the lights only mode, and 5 percent used the two modes equally.

**Experiences with Blind Spot Monitoring alerts:** Almost all drivers said the system alerted them when they changed lanes on all or most (65%), some (20%), or very few (8%) trips, and 79 percent reported it had prevented them from colliding with a vehicle in another lane. Owners who typically used the lights/chime mode were more likely to report that the system had prevented a lane-change crash than those who typically used the lights only mode (82% vs. 67%,  $\chi^2$ [1]=4.2, p=0.040). No owners had collided with another vehicle with their Dodge or Jeep while changing lanes.

Owners were asked how often Blind Spot Monitoring failed to alert them when another vehicle was in one of their side blind spots. About three-quarters of drivers reported the system had never failed to alert them. Seventeen percent of drivers said the system failed to alert them very often or sometimes (5%) or rarely (12%). Among owners who reported them, failures occurred in inclement weather (28%) and when another vehicle approached very quickly (28%) or was too close to their vehicle (22%). The owners' manuals for the study vehicles note that the system will not alert if another vehicle enters a blind spot from behind at a speed of 30 mph or faster than their vehicle, or when passing another vehicle at a

speed of 10 mph or faster than the other vehicle. Snow, ice, and road debris are also known to impair the system's sensors.

Drivers were asked how often the system alerted them when there was not another vehicle in one of their blind spots. Fifty-five percent of drivers said this never occurred, but 38 percent said it occurred very often (2%), sometimes (16%), rarely (19%), or at an unknown frequency (1%). Drivers who received alerts perceived as unnecessary most often said this occurred when driving past stationary roadside objects such as trees and guardrails (66%).

Experiences with Rear Cross Path Detection alerts: Nearly all drivers (97%) reported that the Rear Cross Path Detection alerted them while backing out of a parking space or driveway on all or most (66%), some (19%), or very few trips (12%), and 81 percent said it had prevented them from colliding with another vehicle while backing out of a driveway or parking space. Six owners (3%) reported they had collided with another vehicle with their Dodge or Jeep while backing out of a driveway or parking space. Two of the owners said they were alerted prior to their crash, three were not alerted, and one did not know.

Most owners (75%) reported the system never failed to alert them when it is on and another vehicle is in one of their blind spots as they are backing out of a parking space or driveway; 15 percent reported it failed to alert very often or sometimes (5%) or rarely (10%). Drivers most often said this happened when another vehicle approached from behind very quickly (39%).

Owners were asked how often the system alerted them while backing when there was not a vehicle, person, or other object in one of their blind spots. Rear Cross Path Detection is intended to alert drivers only to moving vehicles but could be beneficial if it detected people or other objects that could potentially be struck. Fifty-nine percent said the system never alerted them unnecessarily, and 34 percent reported experiencing unnecessary alerts very often (5%), sometimes (16%), or rarely (13%). This occurred in inclement weather such as rain or snow (25%); when there were stationary objects off to the side that are not in danger of being struck, such as garage doors or parked cars (25%); and when the sun was rising or setting and/or there was sun glare or shadows (20%).

**Opinions of alerts**: Drivers were asked if they agreed with statements about the systems' chime and warning lights. There were 189 owners who had heard the chime while changing lanes and 203 who

had heard it while backing. Among the owners who had heard the chime in the respective situations, 85 percent agreed it was useful while changing lanes and 95 percent agreed it was useful when backing out of a driveway or parking space. Nearly all (99%) of the 208 owners who had been alerted by Blind Spot Monitoring reported seeing the warning lights while changing lanes, and 95 percent of the 205 owners alerted by Rear Cross Path Detection had seen the warning lights while backing. Of the owners who had seen the warning lights in these situations, 97 percent agreed they were useful while changing lanes and 75 percent agreed they were useful while backing.

Almost all owners (99%) indicated they had heard the chime and seen the warning lights in some circumstances. Of owners who had heard the chime, 11 percent agreed it was annoying, 2 percent agreed it was too loud, and 2 percent agreed it was too quiet. Only 1 percent of owners who had seen the warning lights agreed they were annoying, and 89 percent agreed they were easy to see.

Behavioral responses to systems: All owners were asked if their lane-changing and backing behaviors had changed compared with before they had the systems. Eighty-seven percent of owners said they tended to change lanes with the same frequency, whereas 11 percent indicated they changed lanes more (8%) or less (3%) often. Most (80%) reported no change in their turn signal use when changing lanes, but 17 percent use their turn signal more often and 2 percent use it less often. Although the majority of drivers (58%) reported no change in how often they turned their heads to check blind spots when changing lanes, a substantial percentage (33%) said they turned their heads less often; 8 percent did so more often. Three-quarters of owners said they checked side mirrors when changing lanes with the same frequency, 20 percent checked more often, and 3 percent checked less often.

With regard to the frequency of backing quickly out of a driveway or parking space with the system, 62 percent reported no change, 27 percent backed quickly less often, and 4 percent backed quickly more often. Most (63%) said they parked between large vehicles that block their view with the same frequency, 12 percent did so less often, and 9 percent did so more often. More than three-quarters of drivers (77%) reported no change in how often they parked head-on in a spot they would later have to back out of, whereas 13 percent and 6 percent said they did so more and less frequently, respectively.

### **General Opinions of Systems**

All owners with the systems asked if they would want them again in their next vehicle and if the technologies relieved them from stress or were distracting. Responses are summarized in Table 5. More than 90 percent said they would want each technology again. The percentage of drivers reporting that technologies relieved them of stress while driving ranged from 50 percent for Forward Collision Warning to 74 percent for Blind Spot Monitoring. Fewer than 10 percent of drivers found any of the systems distracting. Owners with Adaptive Cruise Control and Forward Collision Warning were asked if they found these technologies annoying; few owners said either was annoying (7% and 6%, respectively).

In an open-ended question, owners were asked to describe anything they disliked about any of the systems. Twenty-one percent of owners with Adaptive Cruise Control and Forward Collision Warning, and 11 percent of owners with Blind Spot Monitoring and Rear Cross Path Detection, indicated there was something they disliked. The most common complaint was activations of the system that were perceived to be unnecessary (41% and 39% of owners with complaints regarding each set of systems, respectively).

Owners were asked how they learned to use the two sets of systems and could provide multiple responses. The top ways in which drivers learned were the same for owners with either set of technologies, and the answers for both sets were combined. Of the 422 drivers, 77 percent learned from the owner's manual, 54 percent from trying them out on the roadway, and 30 percent from a dealership demonstration. When asked to rate their understanding of how the systems work on a scale of 1-10, with 1 meaning not at all and 10 meaning that they completely understand, significantly more owners surveyed about Blind Spot Monitoring and Rear Cross Path Detection rated their understanding a 10 than owners surveyed about Adaptive Cruise Control and Forward Collision Warning (60% vs. 42%,  $\chi^2$ [1]=13.3, p<0.001).

#### Differences by Driver Age and Gender and Duration of Ownership

**Differences by driver age:** There were some differences by driver age (40 and younger, 41-60, 61 and older), the most notable of which are summarized in Table 6. Trends by age were generally linear. The proportion of drivers who had ever adjusted the Adaptive Cruise Control setting decreased with age, and the percentage that typically used the default long setting ranged from 18 percent of drivers 40 and

younger to 56 percent of drivers 61 and older. Fifty-five percent of drivers 40 and younger reported they followed the vehicle in front less closely when using Adaptive Cruise Control than without the system, compared with 27 percent of drivers 61 and older. Only 12 percent of drivers 40 and younger reported they always or sometimes used Adaptive Cruise Control on lower-speed roads with traffic signals or stop signs, whereas 30 percent of drivers 61 and older always or sometimes used it on those roads.

With regards to Forward Collision Warning, the proportion of drivers who always kept it turned on, had been warned more than once, believed it prevented a collision, and thought their most recent warning came too early decreased with age. The proportion of drivers who reported they completely understood how to operate Forward Collision Warning and Adaptive Cruise Control and the proportion who more often checked their side mirror while changing lanes with Blind Spot Monitoring increased with age. Among drivers alerted by Forward Collision Warning, 84-85 percent of those aged 60 and younger reported they had seen the warning message, compared with 68 of those 61 and older. With age, drivers were less likely to agree that the chimes from Forward Collision Warning and Blind Spot Monitoring/Rear Cross Path Detection were annoying, and to report they had ever been alerted by Blind Spot Monitoring or Rear Cross Path Detection when there was not another vehicle or other relevant object in one of their blind spots.

Differences by driver gender: Table 7 highlights differences in responses by driver gender. Males were more likely to have ever used Adaptive Cruise Control and to have adjusted distance setting on systems that have them. Females most often reported that Rear Cross Path Detection alerted them frequently and has prevented a collision, that the technology has ever alerted them when there is not a vehicle, person, or other object in one of their blind spots; and that their behavior changed with the system. They also most often agreed that systems or their components were annoying, and that Blind Spot Monitoring relieved them of stress.

**Differences by duration of ownership:** It was expected that drivers' opinions of the systems might change as they became more familiar with the systems. Responses were compared between drivers who had owned their vehicles for less than 2 years and drivers who had owned their vehicles for 2 years or more. Drivers who had owned their vehicle for a longer period were more likely to report they very often or sometimes waited for an alert from Forward Collision Warning before slowing when

approaching another vehicle (18% vs. 8%,  $\chi^2$ [1]=4.6, p=0.032). These owners were less likely to report that their most recent forward collision warning came too early (6% vs. 17%,  $\chi^2$ [1]=5.8, p=0.016) and that they have ever been alerted by Rear Cross Path Detection when there is not a vehicle, person, or other object in one of their blind spots (27% vs. 41%,  $\chi^2$ [1]=4.0, p=0.044).

#### DISCUSSION

Collision avoidance technologies have the potential to prevent a substantial proportion of crashes, but they can only be successful if drivers use them consistently and respond to them appropriately. Previous surveys of owners of luxury Volvo and Infiniti vehicles with collision avoidance systems found that drivers keep the systems on most of the time and that the vast majority wanted the technologies again on their next vehicle (Braitman et al. 2010; Eichelberger & McCartt 2014a, 2014b). As these technologies were first implemented on luxury vehicles, it is important to continue to examine how drivers use and accept them as they filter to a wider variety of vehicles. This paper reports the results of a new survey with owners of Dodge and Jeep vehicles with Adaptive Cruise Control, Forward Collision Warning, Blind Spot Monitoring, and Rear Cross Path Detection.

Similar to previous surveys, 95 percent of drivers with Blind Spot Monitoring and Rear Cross Path Detection and 84 percent with Forward Collision Warning always kept the systems turned on. Some owners may have turned their systems off because they became more familiar with their limitations; for example, some owners who ever turned off Forward Collision Warning said they did so because they do not need it on some types of roads. More than 90 percent of owners said they would want each technology again on their next vehicle, which again is similar to the opinions of owners of other systems (Braitman et al. 2010; Cicchino et al. 2014; Eichelberger & McCartt 2014a, 2014b).

There was variation between owners of Dodge and Jeep vehicles and of other vehicles with similar systems in their perceptions of receiving alerts they believed to be unnecessary, and this could be related to differences in the technologies used by the systems and the frequency with which drivers were alerted. Nearly three-quarters of Volvo drivers with a side-view assist system that uses cameras to detect other vehicles reported experiencing alerts that they perceived to be false or unnecessary (Braitman et al. 2010). Fewer Dodge and Jeep drivers with Blind Spot Monitoring, 38 percent, reported being alerted when there is not a vehicle in their blind spot; Blind Spot Monitoring is a radar-based system. Camera-

based sensors tend to be more sensitive than radar to poor visibility conditions such as rain or fog (e.g., Campbell et al. 2007), and Volvo owners with side-view assist reported that perceived false alerts most commonly occurred in inclement weather (Braitman et al. 2010). More than 60 percent of Dodge and Jeep drivers with Forward Collision Warning reported alerts when they believed they were not at risk of colliding with the vehicle in front of them, whereas 16-43 percent of drivers with other forward collision warning systems reported ever receiving alerts that they perceived to be unnecessary (Braitman et al. 2010; Eichelberger & McCartt 2014a, 2014b). Nearly all Dodge and Jeep owners with Forward Collision Warning reported being alerted at least once by the system, compared with 40-81 percent of drivers of other vehicles with forward collision warning systems (Braitman et al. 2010; Eichelberger & McCartt 2014a, 2014b).

If drivers receive unnecessary alerts, it can lessen their trust that an alert represents a genuine threat. However, some owners reported that these alerts occurred at times when they could have been at risk of crashing; for instance, nearly half of drivers with Forward Collision Warning who reported alerts perceived to be unnecessary said they occurred when the vehicle in front slowed to turn. Reports of these alerts also varied by driver age and gender and by duration of ownership, especially from Rear Cross Path Detection, which may reflect differences in perceptions of when alerts are necessary or in driving behavior. More experience with the vehicle also influenced drivers' opinions of the timing of alerts; the percentage of drivers who reported that their most recent alert from Forward Collision Warning came too early declined with longer ownership.

Previous surveys of drivers of luxury vehicles with collision avoidance technologies did not report differences by driver age and gender and duration of ownership (Braitman et al. 2010; Eichelberger & McCartt 2014a), but there were such differences in the current survey. About one-quarter of drivers aged 40 and younger found the chimes from the systems annoying, and this percentage decreased with age. In spite of annoyance, drivers 60 and younger were more likely than older drivers to always keep Forward Collision Warning turned on. Drivers 40 and under also appeared to benefit most from Forward Collision Warning. Nearly all drivers in this age group said they had been alerted by the system more than once, and 80 percent believed it had prevented a collision; similar age effects were found with Toyota owners with forward collision warning with automatic braking (Eichelberger & McCartt 2014b). The risk of striking

a vehicle in a front-to-rear collision, which is the crash type that Forward Collision Warning would be most likely to mitigate, decreases with age (Singh 2003). However, very few owners interviewed in this study and by Eichelberger and McCartt (2014b) were younger than 30. In the future, it will be useful to assess how the youngest, highest-risk drivers use these and other collision avoidance systems.

Younger drivers reported having a greater understanding than older drivers of how to operate Forward Collision Warning and Adaptive Cruise Control. The Adaptive Cruise Control system can only be turned on or resumed after braking at speeds of 20 mph and above, and it is not typically useful on lowerspeed roads with traffic signals or stop signs; yet, nearly a third of drivers 61 and older reported they always or sometimes use the system on these roads. This differs from the findings of a survey of early adopters of adaptive cruise control systems by Jenness et al. (2008), in which drivers 65 and older did not report differences from younger drivers in frequency of use of the systems in stop-and-go traffic or in their understanding of how the systems operated.

There is concern that drivers may become overly reliant on collision avoidance technologies, or that the technologies will lead to other less safe behaviors. Some drivers reported increases in potentially less safe behaviors with the technologies, some of which are described above. A third of drivers with Blind Spot Monitoring said they turn their heads to check blind spots less often while changing lanes compared with before they had the system, and 40 percent of drivers with Forward Collision Warning said they ever wait for an alert from that system before slowing down when approaching another vehicle. Most drivers who reported doing so said they wait for the alert rarely, but the percentage who said they always or sometimes wait for the alert increased with longer duration of ownership. It is possible that some of these drivers confused the Forward Collision Warning alert with the proximity alert from Adaptive Cruise Control that warns drivers that the system's braking is not enough to maintain the pre-set following distance to the vehicle ahead. These alerts looked and sounded identical on the Dodge Charger.

Drivers also reported behaviors with the system that could possibly increase safety. Thirty-six percent of drivers said they follow the vehicle ahead less closely when using Adaptive Cruise Control than without, and more than half of drivers aged 40 and younger said they do so. About a quarter of drivers with Rear Cross Path Detection said they back quickly out of driveways and parking spots less often with

the system than before they had it, and 17 percent of drivers with Blind Spot Monitoring said they use their turn signal when changing lanes more often.

One in five drivers with Blind Spot Monitoring reported they check their side mirrors more often when changing lanes with the system, and the percentage increased with age. This is consistent with reports from Volvo owners with a side-view assist system (Braitman et al. 2010) and a field operational test of a side-view assist system with middle-aged volunteer drivers (Kiefer & Hankey 2008), in which the system was associated with a significant reduction in the percentage of drivers who did not check the left side-view mirror during left lane changes. Older drivers are overinvolved in merging and overtaking crashes (e.g., Mayhew et al. 2006), and side-view assist systems may be especially beneficial to these drivers if the systems direct their attention to their mirrors as well as providing additional information about vehicles in their blind spots.

Some limitations of this study should be noted. The sample of drivers interviewed may not be representative of the population of U.S. drivers. The technologies were optional equipment that drivers chose to purchase, and although their vehicles are not considered luxury vehicles, they were expensive. Suggested retail prices for the model year 2011 Dodge and Jeep vehicles with the technologies ranged from \$30,920-\$49,250 (Automobile Invoice Service 2011), and could have been higher if additional options were purchased. Owners were also older than the general driving population. Twelve percent of survey respondents were 40 and younger, whereas an estimated 42 percent of the general driving population is younger than 40 (Insurance Institute for Highway Safety 2012). Most drivers surveyed had multiple technologies on their vehicles, and may have confused the systems or been unable to differentiate between them when responding to questions about them. For instance, drivers with Rear Cross Path Detection also had a rear parking sensor system and backup camera, and it is possible that their use of the three systems together influenced their opinions of Rear Cross Path Detection.

It is promising that acceptance and consistent use of collision avoidance and related driver assistance systems has generally been high among early adopters, as well as owners of luxury vehicles and non-luxury vehicles who purchased the technologies available as optional equipment. Drivers reported different experiences with the technologies by age and gender, and some of these differences suggest that drivers in the age ranges that are at highest risk for the crash types the technologies were

designed to prevent may be receiving the greatest benefit from them. Reports of over-reliance on technologies were infrequent, but in the case of Forward Collision Warning increased with longer duration of ownership. It will be important to continue to monitor the experiences of drivers of different vehicle types and of various demographic characteristics as the population of users continues to expand, and as current owners gain more experience with the systems.

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	Owners of vehicles with Owners of vehicles			
	Adaptive Cruise Control and	Blind Spot Monitoring with Rear Cross Path Detection		
	Forward Collision Warning			
	(N=213)	(N=210)		
Age				
30 and younger	3	2		
31-40	9	10		
41-50	23	25		
51-60	27	31		
61-70	26	22		
71 and older	9	8		
Unknown	3	1		
Gender				
Male	57	55		
Female	30	32		
Unknown	13	12		
Miles driven in typical week in vehicle				
100 or less	23	25		
101-200	40	29		
201-300	20	20		
301 or more	15	22		
Unknown	2	4		
Number of months vehicle was owned				
12-23	46	49		
24-35	51	46		
36 or more	1	3		
Unknown	1	2		

# Table 1 Characteristics of each group of survey respondents (percentage)

Note: Percentage do not always sum to 100 due to rounding.

# Table 2 Drivers' use of Adaptive Cruise Control

	Percent
Frequency of use of Adaptive Cruise Control	(N=213)
On freeways, expressways, or other high-speed roads	
Always use	54
Sometimes use	32
Rarely use	6
On lower-speed roads with traffic signals or stop signs	
Always use	8
Sometimes use	14
Rarely use	18
Never use	7
Unknown	1
Typical setting for following distance among those who	(N=196)
ever used Adaptive Cruise Control	
Long (default setting) or never changed	42
Medium	23
Short	31
Use all equally	2
Unknown	1

Note: Percentage do not always sum to 100 due to rounding.

**Table 3** Drivers' use of Forward Collision Warning

Percent
(N=213)
84
11
<1
5
(N=212)
89
7
3
1

Note: Percentage do not always sum to 100 due to rounding.

# Table 4 Drivers' use of Blind Spot Monitoring and Rear Cross Path Detection

	Percent
Frequency of use of Blind Spot Monitoring and Rear Cross Path Detection	(N=210)
Never drive with system off	95
Sometimes or rarely drive with system off	4
Always drive with system off	0
Unknown	1
Frequency of looking at warning light in side mirror when changing lanes	
Always	80
Sometimes	16
Rarely or never	3
Unknown	1
Warning setting typically used	
Lights/Chime	67
Lights Only	20
Use both equally	5
Unknown	8
Note: Development of the second state of the second line is the second state of the se	

Note: Percentage do not always sum to 100 due to rounding.

## Table 5 Drivers' opinions of systems (percentage)

	Adaptive	Forward		Rear
	Cruise	Collision	Blind Spot	Cross Path
	Control	Warning	Monitoring	Detection
	(N=213)	(N=213)	(N=210)	(N=210)
Would want technology again	92	92	99	97
Technology relieves stress when driving	62	50	74	71
Technology is distracting	4	7	2	2

				p-value of
	40 and		61 and	chi-square
	younger	41-60	older	statistic
Among drivers with Adaptive Cruise Control and Forward	N=25	N=105	N=76	
Collision Warning				
Always or sometimes use Adaptive Cruise Control on	12	17	30	0.018
lower-speed roads with traffic signals and stop signs				
Never drive with Forward Collision Warning off	88	90	74	0.011
Completely understand how to operate Forward	64	42	36	0.024
Collision Warning and Adaptive Cruise Control				
Among drivers who ever used Adaptive Cruise Control	N=22	N=96	N=71	
Ever adjusted setting	91	79	63	0.003
Typically use default Long setting	18	36	56	<0.001
Follow less closely	55	41	27	0.010
Look away from the road less often	14	3	1	0.025
Among drivers who used Forward Collision Warning	N=25	N=104	N=76	
Have been alerted more than once	96	85	75	0.012
Has ever prevented collision	80	55	46	0.006
Among drivers ever alerted by Forward Collision	N=25	N=99	N=68	
Warning				
Most recent warning came too early	16	16	1	0.007
Chime is annoying	24	13	6	0.016
Have seen warning message	84	85	68	0.019
Among drivers with Blind Spot Monitoring and Rear	N=26	N=118	N=64	
Cross Path Detection				
More often check side mirror when changing lanes	8	19	28	0.028
Have received alert from Blind Spot Monitoring when	54	42	23	0.003
there is not a vehicle in blind spot				
Have received alert from Rear Cross Path Detection	38	40	20	0.023
when there is not a vehicle, person, or other object				
in blind spot				
Among drivers who had ever heard chime from Blind	N=25	N=117	N=64	
Spot Monitoring and Rear Cross Path Detection				
Chime is annoying	28	<u>1</u> 0	5	0.004

# Table 6 Differences in experiences with systems by driver age (percentage)

			p-value of chi-
	Males	Females	square statistic
Among drivers with Adaptive Cruise Control and Forward	N=121	N=64	
Collision Warning			
Ever used Adaptive Cruise Control	97	83	0.001
Always or sometimes use Adaptive Cruise Control on	93	72	<0.001
freeways, expressways, and other high-speed roads			
Forward Collision Warning is annoying	2	11	0.016
Among drivers who ever used Adaptive Cruise Control	N=117	N=53	
Ever adjusted setting	84	57	<0.001
Among drivers who used Forward Collision Warning	N=121	N=63	
Ever adjusted setting	14	3	0.021
Among drivers with Blind Spot Monitoring and Rear Cross	N=116	N=68	
Path Detection			
Alerted while backing on all, most, or some trips	82	93	0.043
Has ever prevented backing crash	78	91	0.019
Have received alert from Rear Cross Path Detection	26	43	0.019
when there is not a vehicle, person, or other object in			
blind spot			
More often park between vehicles that block view	6	15	0.050
More often park head on in spaces will later have to	9	22	0.018
back out of			
Blind Spot Monitoring relieves stress when driving	69	82	0.046
Among drivers who had ever heard chime from Blind Spot	N=115	N=67	
Monitoring and Rear Cross Path Detection			
Chime is annoying	6	18	0.012

# Table 7 Differences in experiences with systems by driver gender (percentage)