What's in a name? Drivers' perceptions of the use of five SAE Level 2 driving automation systems

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Abstract

Introduction: Automobile manufacturers are developing increasingly sophisticated driving automation systems. Currently, the highest level of automation that is available on the market is SAE Level 2, which provides sustained assistance for both lateral and longitudinal vehicle control functions. Level 2 systems exist under a variety of brand names. The brand name is one piece of information about a system. The purpose of this study was to evaluate how drivers' perceptions of what behaviors secondary to driving are safe while a Level 2 system is operating vary by system name.

Methods: A nationally representative telephone survey of 2,005 drivers was conducted in 2018 with questions about behaviors respondents perceived as safe while a Level 2 driving automation system is in operation. Each respondent was asked about two out of five system names at random for a balanced study design. Respondents also were asked about Level 2 systems in general and about their own vehicle and driving.

Results: The name "Autopilot" was associated with the highest likelihood that drivers believed a behavior was safe while in operation, for every behavior measured, compared with other system names. Many of these differences were statistically significant. There was less variation observed among the other four SAE Level 2 system names when compared with each other. A limited proportion of drivers had experience with advanced driver assistance systems: 9–20% of respondents reported having at least one crash avoidance technology such as forward collision warning or lane departure warning, and fewer of these reported driving a vehicle in which Level 2 systems were available. Drivers reported that they would consult a variety of sources for information on how to use a Level 2 system.

Conclusions: The names of SAE Level 2 driving automation systems influence drivers' perceptions of how to use them, and the name "Autopilot" was associated with the strongest effect. While a name alone cannot properly instruct drivers on how to use a system, it is a piece of information and must be considered so that drivers are not misled about the correct usage of these systems.

Practical Applications: Manufacturers, suppliers, and organizations regulating or evaluating SAE Level 2 automated driving systems should ensure that systems are named so as not to mislead drivers about their proper use.

Keywords: driving automation systems; SAE Level 2; branding; automation; advanced driver assistance systems

1. Introduction

Through his character, Juliet, who famously mused that "a rose, by any other word would smell as sweet", Shakespeare suggested that, among other things, a name has little to do with what constitutes a person or item. While there is a certain wisdom in that, the same does not hold true for people's impressions and expectations of an item. For example, referring to a rose as say, a supercomputer, would be misleading. While such an action would not fundamentally change the rose in question, it clearly would change people's impressions of what the rose can do, what it smells like, and so on—at least until further inspection. In fact, one study found that using different names for smell samples affected peoples' ratings of their pleasantness (Djordjevic et al., 2008). So, names can convey information and they do matter to a certain degree.

The name of an automotive system, whether a specific brand name or part of a structured nomenclature (e.g., American Automobile Association [AAA], 2019), ideally should be descriptive about the system but must never mislead drivers about its correct use. For example, terms such as "side airbag" and "speedometer" clearly convey the purpose and function of those systems, albeit without providing a full description of their use. The name of a system, especially one more complicated than a speedometer, cannot fully convey the proper use of that system to the driver, yet system name is an important piece of information and should not be overlooked. Furthermore, the name often is the first piece of information about a system that a driver is exposed to. As driver assistance and vehicle automation technology advance, it is increasingly important to avoid misinforming drivers on the proper use of these systems. Drivers' initial mental models, before using the systems, can influence how they learn to use them (Kazi, Stanton, Walker, & Young, 2007). This issue likely is compounded if drivers do not receive any formal training during the purchasing process. For instance, fewer than half of respondents in a recent survey were offered training at the dealership for adaptive cruise control (ACC) systems equipped on vehicles they purchased (AAA Foundation for Traffic Safety, 2018).

Drivers do not always understand the limitations of the technologies in their vehicles. A recent study revealed that drivers of vehicles equipped with driver assistance features had favorable impressions

of the technologies when asked about them by their generic names. However, these drivers lacked awareness of what the technologies can and cannot do and reported being willing to engage in other activities secondary to driving, to look away from the roadway, or to otherwise overly rely on the technologies (AAA Foundation for Traffic Safety, 2018). In particular, 13% of drivers reported that they would feel comfortable engaging in other activities at least sometimes while using adaptive cruise control (ACC), which uses sensors to maintain a minimum following distance in addition to a set speed. The figure was 14% for lane keeping assist (LKA), which monitors lane lines and guides the vehicle back into the lane if it begins to depart. LKA differs from lane-centering (LC) technology in that the latter provides sustained assistance and tries to keep the vehicle centered, rather than reacting only when the vehicle drifts near or onto the lane line. These results are consistent with other studies showing that drivers do not fully understand the limitations of these systems (ACC in particular) or how much trust in the system is appropriate (; Dickie and Boyle, 2009; Kazi et al., 2007; Larsson, 2012; McDonald et al., 2016).

These advanced driver assistance technologies form the basis of current and future driving automation technology. Driving automation technologies have been classified in a six-level system by SAE International (2018). The first three levels assume that the driver monitors the roadway with full attention and is able to perform or resume all aspects of vehicle control at any moment: Level 0 represents no sustained automation, Level 1 represents sustained automation of either lateral (i.e., lane keeping) or longitudinal (i.e., speed and following distance) control, and Level 2 represents sustained automation of both lateral and longitudinal control. The remaining three levels assume that the vehicle takes over responsibility for monitoring the roadway: Level 3 is like Level 2, except that the human driver is expected to be ready to respond to a request to intervene issued by the driving automation system; Level 4 does not assume that the driver will be requested to intervene while in certain operational design domains (e.g., on specially mapped controlled-access roads); and Level 5 is like Level 4, except without any constraint on the operational design domain. Most vehicles currently on the road operate only at Level 0. ACC and LC are examples of Level 1 automation. Level 2 functionality can be achieved by engaging both ACC and LC, if equipped, but there is an increasing number of Level 2 systems on the market in

which both lateral and longitudinal control are integrated to work together. Currently, no vehicles for sale in the United States have Level 3 or higher driving automation capability.

There is greater potential for drivers to misuse Level 2 driving automation systems than for ACC. For instance, a review of research on the effects of highly automated driving and ACC on drivers' situational awareness and behavior (de Winter, Happee, Martens, & Stanton, 2014) found that drivers were more likely to engage in tasks unrelated to driving when operating highly automated vehicles (by their descriptions, these can be inferred to mean Level 2 vehicles) than with ACC alone or during manual driving. Engagement in nondriving tasks was found to result in deteriorated situational awareness. Drivers' engagement in distracting behaviors while operating highly automated vehicles has been observed on test tracks and in simulators (Carsten, Lai, Barnard, Jamson, & Merat, 2012; Llaneras, Salger, & Green, 2013). Moreover, the need for drivers to devote full attention when using Level 2 systems is not simply an issue of designer intent but is necessitated by the actual performance of these systems. Researchers conducted on-road tests designed to study the performance of five vehicles with Level 2 systems in roadway situations identified as challenging to these systems that human drivers encounter frequently—in particular, curves and hills (Insurance Institute for Highway Safety [IIHS], 2018). These systems exhibited potentially serious issues such as crossing lane lines, disengagement, and erratic steering. While there was no clear leader, the performance of these five systems clearly indicated the need for constant driver supervision and intervention.

Researchers have studied drivers' perceptions of driving automation system functionality based on the system's name and terms used to describe it. One study found that the name of a system affected drivers' perceptions of the system's level of automation (Abraham, Seppelt, Mehler, & Reimer, 2016b). The study found that names such as "Autopilot" and "ProPilot" were associated with higher levels of perceived automation than other system names on the market, but differences were not statistically tested since the primary goal was to measure correct classification of automation level and not to directly compare names. Names containing the term "cruise" were associated with lower levels of automation, and those containing "assist" varied more widely. Another study found that the term "Autopilot" was not

significantly different than the terms “high automation”, “autonomous”, and “self-driving”, with respect to how subjects rated the balance of responsibility between vehicle and human drivers (Nees, 2018). These terms were rated higher on this scale than terms such as “PilotAssist”, “Copilot”, and “Driver Assistance”.

While potential future users predicting the level of automation of various systems is informative, another approach is to consider what drivers can and cannot safely do while systems operate. In light of the potential for drivers to misunderstand or overly trust Level 2 driving automation systems, the purpose of the current study was to evaluate how drivers’ perceptions of what behaviors are safe while a Level 2 system is operating vary by system name.

2. Methods

A nationally representative telephone (both landline and cellphone) survey was conducted by Opinion America Group during October to November 2018 in the United States. To be included in the sample, respondents had to be at least 18 years old and report that they have driven an automobile within the past month. The cooperation rate was 39% (2,005 completed the survey, out of 5,098 contacted, and 48,283 were attempted in total). The study protocol was deemed exempt from review by IntegReview IRB. The survey instrument included questions about behaviors secondary to driving (by system name), whether drivers would try operating systems inappropriately, where drivers would seek out information about a system, and information about their own vehicles.

The names of five SAE Level 2 systems, all of which are currently available on the market, were investigated: Autopilot (Tesla), Traffic Jam Assist (Audi, Acura), Super Cruise (Cadillac), Driving Assistant Plus (BMW), and ProPilot Assist (Nissan). All these systems provide continuous automated control of speed, following distance, and steering, but they all have limitations and drivers are expected to pay full attention and take over vehicle control should the need arise. Additionally, all of these systems except for Super Cruise require the driver’s hands to be on the steering wheel during operation and will warn the driver if hand-on-wheel contact is not detected after some number of seconds. Super Cruise

instead uses a camera to monitor the driver's gaze direction and warns if the driver is not looking forward. Repeated warnings generally result in systems being disengaged as a deterrent to drivers ignoring the warnings.

Once deemed eligible, participants were told the survey was about "recent technology that helps your vehicle maintain its lane, speed, and following distance" and then asked about two of the five system names at random and in random order. For each name, participants were asked which of the behaviors in Table 1 (the list was read to them) they think would be safe to do while the system is in operation. They were then asked if they had heard of the system before. These two questions were then repeated for the second system name.

In the study's counterbalancing scheme, there were 20 permutations of two of the five system names, with the overall sample size of 2,005 resulting in about 200 participants who were asked about each pair of names (100 in each order) and about 800 who were asked about each single name. Results for comparing reported behaviors considered safe by system name were presented by first reporting the percent of participants indicating which they considered safe for each system name (n of about 800 per name) and then differences were presented as relative percentages and tested against unity using McNemar's test for only those drivers who were asked about both system names (n of about 200 per pair). This method ensured that each test was entirely within-subject and eliminated any possible person-to-person variability. Tests with p values less than 0.05 were considered statistically significant.

Participants were then asked about other situations in which they would use such a system (in general, not by name) and where they would seek out information on how and where to use it, as well as if they had ever used such a system before. They then were asked about the vehicle (make/model/year) they most frequently drive, which of several crash avoidance technologies it is equipped with, and which of the behaviors in Table 1 (except for napping) they have engaged in during the past year of driving. Vehicle make/model/year were mapped to a vehicle features database maintained by the Highway Loss Data Institute to verify that reported technologies were available on reported vehicles. To gauge respondents' familiarity with driving automation technology, even if not Level 2, two groups were

defined: drivers considered familiar were those who reported having adaptive cruise control (ACC) on the vehicle they most frequently drove and reported a vehicle for which it was available as standard or optional equipment, and drivers considered unfamiliar were those who reported not having ACC and reported driving a vehicle where ACC was not available.

Finally, respondents were read a more technical definition of SAE Level 2 driving automation and asked what they would name such a system. The definition was as follows:

> The systems we've been discussing, also known as SAE Level 2 driving automation, use information from sensors—like camera and radar—to help the driver keep the vehicle in the center of the lane and help the driver maintain a set speed and following distance to the vehicle ahead. Sometimes, these systems have trouble detecting stopped vehicles, negotiating curves, or operating in poor weather or roadway conditions and may shut off unexpectedly at any time.

These results were coded as serious responses, negative responses, and unknown. Additionally, text substring searches were conducted on some of the more frequently used terms.

3. Results

Table 1 presents the percent of participants who considered various behaviors to be safe while a SAE Level 2 system is operating, by system name. Across all system names, the most commonly reported behavior was talking with a passenger, followed by adjusting the stereo, and these did not vary strongly by system name. Autopilot was associated with the highest likelihood that drivers believed a behavior was safe while in operation, for every behavior measured. Many of these differences were statistically significant (Table 2a). There was less variation evident among the other four system names when compared with each other, as evidenced by the smaller estimated differences and lower numbers of statistically significant differences (Tables 2b–2d).

Table 1. Percent of drivers who considered behaviors to be safe while a Level 2 system is in operation

	Autopilot (n=800)	Traffic Jam Assist (n=801)	Super Cruise (n=802)	Driving Assistant Plus (n=805)	ProPilot Assist (n=802)
Talking with a passenger	68%	61%	64%	65%	60%
Adjusting the stereo	58%	50%	54%	54%	55%
Foot not near the pedals	37%	25%	37%	25%	30%
Hands off the steering wheel	48%	21%	27%	27%	33%
Looking at scenery	36%	25%	29%	31%	32%
Talking on a cellphone	34%	22%	26%	27%	26%
Texting	16%	9%	9%	10%	9%
Reading a book/magazine/newspaper	8%	4%	3%	4%	3%
Watching a video/movie on a cellphone/device	8%	3%	4%	4%	4%
Using a laptop/tablet computer	7%	3%	3%	4%	4%
Taking a nap	6%	3%	3%	3%	3%

Table 2a. Relative percentage of drivers who considered behaviors to be safe while Autopilot is in operation versus the four remaining Level 2 systems

	Traffic Jam Assist (n=199)	Super Cruise (n=200)	Driving Assistant Plus (n=202)	ProPilot Assist (n=199)
Talking with a passenger	1.18*	1.05	1.01	1.05
Adjusting the stereo	1.23*	1.06	1.12*	1.08
Foot not near the pedals	1.39*	1.13	1.79*	1.25*
Hands off the steering wheel	2.78*	1.77*	1.48*	1.31*
Looking at scenery	1.61*	1.43*	1.22	1.12
Talking on a cellphone	1.50*	1.25*	1.15	1.20*
Texting	1.53	1.77*	1.65*	1.77*
Reading a book/magazine/newspaper	2.00*	6.67*	2.43*	1.86
Watching a video/movie on a cellphone/device	1.78	2.25*	2.00*	2.33*
Using a laptop/tablet computer	1.27	2.29*	1.88	1.38
Taking a nap	1.71	2.17*	2.00	1.50

* Statistically significant at the 0.05 level (via McNemar's test).

Table 2b. Relative percentage of drivers who considered behaviors to be safe while Traffic Jam Assist is in operation versus the three remaining Level 2 systems

	Super Cruise (n=200)	Driving Assistant Plus (n=200)	ProPilot Assist (n=202)
Talking with a passenger	1.05	0.85*	1.02
Adjusting the stereo	0.90*	0.96	0.92
Foot not near the pedals	0.65*	0.94	0.81*
Hands off the steering wheel	0.77	0.79	0.73*
Looking at scenery	0.80	0.95	0.89
Talking on a cellphone	0.92	0.88	0.86
Texting	1.13	0.90	1.12
Reading a book/magazine/newspaper	0.86	0.89	1.00
Watching a video/movie on a cellphone/device	0.75	1.17	1.00
Using a laptop/tablet computer	0.75	0.38*	0.75
Taking a nap	1.33	1.25	1.00

* Statistically significant at the 0.05 level (via McNemar's test).

Table 2c. Relative percentage of drivers who considered behaviors to be safe while Super Cruise is in operation versus the two remaining Level 2 systems

	Driving Assistant Plus (n=202)	ProPilot Assist (n=200)
Talking with a passenger	0.99	1.06
Adjusting the stereo	0.94	0.95
Foot not near the pedals	1.35*	1.30*
Hands off the steering wheel	0.76*	0.84
Looking at scenery	0.96	0.85
Talking on a cellphone	0.97	0.88
Texting	0.60*	0.82
Reading a book/magazine/newspaper	0.56	1.80
Watching a video/movie on a cellphone/device	0.83	0.64
Using a laptop/tablet computer	0.86	0.67
Taking a nap	0.67	3.00

* Statistically significant at the 0.05 level (via McNemar's test).

Table 2d. Relative percentage of drivers who considered behaviors to be safe while Driving Assistant Plus is in operation versus ProPilot Assist

	ProPilot Assist (n=201)
Talking with a passenger	1.07
Adjusting the stereo	1.01
Foot not near the pedals	1.04
Hands off the steering wheel	0.75*
Looking at scenery	0.95
Talking on a cellphone	0.86
Texting	1.17
Reading a book/magazine/newspaper	0.86
Watching a video/movie on a cellphone/device	0.80
Using a laptop/tablet computer	1.00
Taking a nap	0.71

* Statistically significant at the 0.05 level (via McNemar's test).

Close to half (44%) of respondents who were asked about Autopilot reported that they had heard of it, followed by Driving Assistant Plus (19%), ProPilot Assist (15%), Traffic Jam Assist (11%), and Super Cruise (10%).

Between 9 and 20% of respondents reported having at least one of the crash avoidance technologies (Table 3) they were asked about on the vehicle they most frequently drive. When examining availability of these features on the vehicle (make/model/year) they reported, only about half of those with automatic emergency braking (AEB) reported driving vehicles possibly equipped with the feature. Plausible responses (i.e., vehicles possibly equipped with the reported feature) were more likely for warning systems (FCW, LDW, BSW) than for systems that intervene in some way (AEB, LKA/LC), as presented in Table 4. This may reflect the concept that warnings generally happen in lower severity situations than in interventions, and thus would be more frequent. ACC was reported at a lower accuracy rate similar to AEB and LKA/LC, possibly indicating confusion with conventional cruise control.

Table 3. Crash avoidance technologies respondents reported having in the vehicles they most frequently drive and availability based on the vehicle make/model/year they reported

	Said they have (n=2,005)	Among those who reported having the feature, its availability on the vehicle they said they drive as standard or optional (n=1,639)
Automatic emergency braking (AEB)	18%	46% (n=286)
Forward collision warning (FCW)	14%	74% (n=228)
Adaptive cruise control (ACC)	19%	44% (n=316)
Lane departure warning (LDW)	14%	69% (n=230)
Lane keeping assist/lane centering (LKA/LC)	9%	43% (n=148)
Blind spot warning (BSW)	20%	67% (n=319)

Among those who did not report that their vehicle had one of the systems studied (n=1,874), 182 drivers (10%) reported that they tried a vehicle with "one of these systems or something similar" [data not shown in tables]. Of these, based on the make/model/year of the vehicle they reported trying, only 46% were in vehicles that had ACC as standard/optional equipment and so would not have been equipped with a Level 2 system.

Table 4 presents behaviors respondents reported as safe across all Level 2 system names studied by ACC experience. Respondents with ACC in their most frequently driven vehicle were generally more likely to report behaviors as safe while a Level 2 system operates.

Table 4. Behaviors drivers reported as safe while a Level 2 system operates by ACC familiarity

	All (n=2,005)	With ACC in their own car (n=140)	Without ACC in their own car (n=1,040)
Talking with a passenger	64%	65%	65%
Adjusting the stereo	56%	60%	56%
Foot not near the pedals	28%	35%	26%
Hands off the steering wheel	30%	34%	28%
Looking at scenery	30%	25%	31%
Talking on a cellphone	28%	31%	29%
Texting	9%	12%	8%
Reading a book/magazine/newspaper	4%	5%	4%
Watching a video/movie	4%	6%	4%
Using a laptop/tablet computer	4%	6%	3%
Taking a nap	3%	5%	2%

Table 5 presents the same list of behaviors, with the exception of taking a nap, reported during the past year of driving. Several behaviors were more likely reported in actual driving than were reported safe while a Level 2 system is operating. These included talking with a passenger, adjusting the stereo, texting, talking on a cellphone, and looking at scenery. With the exception of looking at scenery, percentages were higher for all behaviors among drivers with ACC, compared with those without ACC. The largest difference was for foot not near the pedals.

Table 5. Behaviors reported during past year of driving by ACC familiarity

	All (n=2,005)	With ACC in their own car (n=140)	Without ACC in their own car (n=1,040)
Talking with a passenger	76%	84%	76%
Adjusting the stereo	70%	70%	71%
Foot not near the pedals	16%	27%	13%
Hands off the steering wheel	13%	16%	11%
Looking at scenery	50%	44%	51%
Talking on a cellphone	43%	51%	43%
Texting	18%	18%	17%
Reading a book/magazine/newspaper	1%	3%	1%
Watching a video/movie	2%	5%	2%
Using a laptop/tablet computer	1%	3%	<1%

When asked about a Level 2 system that "requires eyes on road, hands on wheels, full attention, but works pretty well", 28% said that there are situations where they would trust the system and look away to do another task. If a system is recommended for use only on certain roads and in specific situations but doesn't prevent a driver from using it elsewhere, 29% said they would try using it outside those conditions.

Respondents were asked where they would seek out information on how to use a Level 2 system and, if there are places or situations in which they should not use the system, how they would know where the system should not be used. The most frequently cited source for both was the vehicle owner manual, by about three quarters of respondents (Table 6). The manufacturer's website was cited by over half of

respondents to both questions. Consumer information websites, YouTube videos, and experimenting with the vehicle all were common responses as well. While the owner manual was cited as the primary source of information on how to use the system by over half of respondents, these results show that they would consult a variety of sources. Over half of respondents cited "vehicle won't let you engage it" as how they would know not to use a Level 2 system in a given situation. Eleven percent reported that they would not buy a vehicle with such a system.

Table 6. Sources of information on how to use Level 2 systems and on how to know they should not be used in certain situations

	On how to use the Level 2 system [primary %] (n=2,005)	On where the system cannot be engaged (n=2,005)
Owner manual	76% [54%]	70%
Manufacturer website	60% [14%]	51%
Consumer information websites	38% [5%]	36%
Watching YouTube videos	36% [7%]	22%
Learn from experimenting with the vehicle	38% [8%]	30%
Vehicle won't let you engage it	n/a	56%
I wouldn't buy one	11% [10%]	n/a

Finally, when read a more substantial definition of SAE Level 2 driving automation and asked to name it, most respondents (1,396, or 70%) provided some sort of serious answer. The most commonly used word was "assist" (527, or 26%), followed by "drive" (515, or 26%), and both "drive" and "assist" appeared in 276 (14%) responses (e.g., "Driver Assist", "Driving Assistant", "Auto Drive Assist - ADA"). About 15% of respondents gave some sort of negative response (e.g., "Accident Assist", "unreliable", "Suicide Switch", "Yamdut [in Hinduism, a representative of the god of death]"). The remaining 15% were not able to be classified as serious or negative (e.g., no answer, "do not have any idea", "Sally").

4. Discussion

The results of this study show that the names of SAE Level 2 driving automation systems influence drivers' perceptions of how to use them, in terms of what behaviors they believe would be safe while a system is operating. The name "Autopilot", in particular, stood out with respondents who reported higher levels of perceived safe behaviors than for the four other systems—which were not very different from each other. The current study adds to the growing body of evidence (Abraham et al., 2016b; Nees, 2018) that "Autopilot" is a misleading name for a Level 2 driving automation system.

The term "Autopilot" comes from aviation, where autopilot systems on airplanes help reduce pilot workload by automating tasks such as maintaining or changing altitude or heading, but pilots must be ready to resume control and fly the aircraft manually at any moment (Federal Aviation Administration, 2009). So even though autopilots in no way replace human pilots, that is exactly the connotation the term "autopilot" typically brings to mind, as well as its colloquial usage. Automation, especially in the form of autopilots, has a much longer history in aviation than in surface transportation. While piloting a plane and driving an automobile differ in many ways, there likely is opportunity to apply lessons learned (i.e., how humans and automation interact, and automation system design and human factors considerations) found in the aviation safety literature to driving automation systems for on-road motor vehicles.

Some behaviors, namely talking on a cellphone and texting, were much more common during respondents' past year of driving, compared with being identified as safe behaviors while a Level 2 system is in operation. There are a few possible explanations for this pattern of results. One is that drivers underestimate what behaviors they would actually do if they had these Level 2 systems. Another is simply that the questions differ: the Level 2 question asked what is a safe behavior, whereas the past year of driving question simply asked which behaviors they did engage in. Drivers have been known to self-report engaging in behaviors that often are considered unsafe such as talking on a cellphone, texting, and using a smartphone for watching videos or video chat at rates similar to those observed in the current study (Schroeder, Wilbur, & Peña, 2018). The pattern noted above also could arise if drivers believe they would not trust these systems. One study found that drivers were somewhat more likely to report they

would engage in various distracting behaviors such as cellphone use, watching videos, and using a laptop/tablet while driving if these were legal (National Safety Council, 2016), compared with what drivers in the current study reported would be safe to do while operating a Level 2 system.

While drivers may be wary of automation (AAA, 2018; Abraham et al., 2016a; Kidd & Reagan, 2018), other research has found that drivers are likely to engage in nondriving tasks while using SAE Level 2 driving automation on a test track or in a simulator or otherwise overly rely on these systems. For instance, Carsten et al. (2012) found that 32% of drivers in a simulator used a DVD player while operating a partially automated vehicle. Llaneras et al. (2013) found that over half of participants reached for the rear compartment or ate while operating a partially automated vehicle on a test track for 1.5–2 hours, and 50% of the participants texted. Omae, Hashimoto, Sugamoto, and Shimizu (2005) found that eight of 30 participants fell asleep while operating an automated vehicle (with automation that seems like Level 2, although possibly was Level 3) on a test track, even though they were told steering failures requiring manual intervention were possible. A recent study (Banks , Eriksson, O'Donoghue, & Stanton, 2018) found that participants operating a Tesla Model S using Autopilot demonstrated behavior indicative of complacency with or overtrust in the Level 2 system—in particular, most drivers were observed to operate Autopilot completely hands-free, only placing their hands on the wheel because of system warnings.

About half of drivers in the current study reported that simply being unable to engage a Level 2 system is how they would expect to know where it should not be used. A recent survey compared how drivers would prefer to learn how to use various technologies, versus how they reported actually having learned to use them, on their current vehicles (Abraham et al., 2016a). These drivers reported they would have preferred to learn from the dealership at the time of purchase, from websites, and from the vehicle teaching them. Certainly, restricting drivers from engaging Level 2 systems outside of the operational design domain is the most effective way to ensure these systems are operated only in the right locations, and this approach fits with drivers' expectations. However, defining the operational design domain may be more complicated than just locations and road types and may involve other factors that are more

difficult for a vehicle to self-enforce. Moreover, some researchers believe that drivers may better learn the systems' limits if they experience the limitations themselves outside of the operational design domain (Heimbeck, Frese, Sonnentag, & Keith, 2003; Sullivan , Flannagan, Pradhan, & Bao, 2016) and this would be especially important if simply restricting the vehicle to its operational design domain is not fully possible.

The negative responses to the question asking people to assign a name based on a careful definition of Level 2 driving automation possibly highlights the idea that people need to better understand how using an imperfect automation system benefits them. It is easy to see how a Level 4/5 vehicle, if they were available and functioned as such, would be beneficial, but the benefits are less obvious if the driver has to pay the same amount of attention as he or she does in manual driving. Since the study found that people report they would use a variety of sources of information to learn to use these systems, including owner manuals, manufacturer websites, consumer information websites, and YouTube, there is a variety of ways to inform people.

The main limitation of the current study is that measuring people's perceptions about Level 2 systems does not necessarily predict how they actually would use Level 2 systems. While those are different research questions, actual use is what determines safety benefits and disbenefits. In particular, while Autopilot was associated with higher levels of all investigated behaviors being perceived as safer than other systems, this study does not provide any evidence that people using Autopilot actually conduct these behaviors at a higher rate than for other Level 2 systems. Other factors likely have larger influences on actual behavior when operating one of these systems than the name of the system, and these factors should be further researched. However, since system name is a piece of information and influences perceptions, it is important that names be developed so as not to mislead drivers about the systems' correct use. Manufacturers and suppliers should take this into consideration as should organizations that regulate or evaluate these systems.

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References

American Automobile Association. (2018). Vehicle technology survey—Phase IIIB.

American Automobile Association. (2019). *Advanced driver assistance technology names: AAA's recommendation for common naming of advanced safety systems*. Retrieved from https://www.aaa.com/AAA/common/AAR/files/ADAS-Technology-Names-Research-Report.pdf

AAA Foundation for Traffic Safety. (2018). *Vehicle owners' experiences with and reactions to advanced driver assistance systems*. Retrieved from https://aaafoundation.org/wp-content/uploads/2018/09/VehicleOwnersExperiencesWithADAS_TechnicalReport.pdf

Abraham, H., Lee, C., Brady, S., Fitzgerald, C., Mehler, B., Reimer, B., & Coughlin, J.F. (2016a). *Autonomous vehicles, trust, and driving alternatives: A survey of consumer preferences*. Cambridge, MA: Massachusetts Institute of Technology AgeLab.

Abraham, H., Seppelt, B., Mehler, B., & Reimer, B. (2016b). What's in a name: vehicle technology branding & consumer expectations for automation. *Proceedings of the 9th ACM International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, September 24–27, Oldenburg, Germany.

Banks, V.A., Eriksson, A., O'Donoghue. J., & Stanton, N.A. (2018). Is partially automated driving a bad idea? Observations from an on-road study. *Applied Ergonomics*, *68*, 138–145.

Carsten, O., Lai, F.C., Barnard, Y., Jamson, A.H., & Merat, N. (2012). Control task substitution in semiautomated driving. Does it matter what aspects are automated? *Human Factors, 54*, 747–761.

de Winter, J.C.F., Happee, R., Martens, M.H., & Stanton, N.A. (2014). Effects of adaptive cruise control and highly automated driving on workload and situation awareness: A review of the empirical evidence. *Transportation Research Part F, 27*, 196–217.

Dickie, D.A., and Boyle, L.N. (2009). Drivers' understanding of adaptive cruise control limitations. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *53*(23), 1806–1810.

Djordjevidk, J., Lundstrom, J.N., Clément, F., Boyle, J.A., Pouliot, S., & Jones-Gotman, M. (2008). A rose by any other name: Would it smell as sweet?, *Journal of Neurophysiology, 99*, 386–393.

Federal Aviation Administration,. (2009). *Advanced avionics handbook* (Report No FAA-H-8083-6). Washington, DC: U.S. Department of Transportation.

Heimbeck, D., Frese, M., Sonnentag, S., & Keith, N.. (2003). Integrating errors into the training process: The function of error management instructions and the role of goal orientation. *Personnel Psychology, 56*(2), 333–361.

Highway Loss Data Institute. (2018). Compendium of HLDI collision avoidance research. *Bulletin,* 35(34).

Insurance Institute for Highway Safety. (2018). Road, track tests to help IIHS craft ratings program for driver assistance features, *Status Report*, *53*(4), 3–5.

Kazi, T.A., Stanton, N.A., Walker, G.H., Young, M.S. (2007). Designer driving: drivers' conceptual models and level of trust in adaptive cruise control. *International Journal of Vehicle Design, 45*(3), 339–360.

Kidd, D.G., & Reagan, I.J. (2018). System attributes that influence reported improvement in drivers' experiences with adaptive cruise control and active lane keeping after daily use in five production vehicles. Arlington, VA: Insurance Institute for Highway Safety.

Larsson, A. (2012). Driver usage and understanding of adaptive cruise control. *Applied Ergonomics, 43,* 501–506.

Llaneras, R.E., Salger, J., & Green, C.A. (2013). Human factors issues associated with limited ability autonomous driving systems: Drivers' allocation of visual attention to the forward roadway.

Proceedings of the 7th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design, Bolton Landing, NY, 92–98.

McDonald, A.B., McGehee, D.V., Chrysler, S.T., Askelson, N.M., Angell, L.S., & Seppelt, B.D. (2016). National survey identifying gaps in consumer knowledge of advanced vehicle safety systems, *Transportation Research Record: Journal of the Transportation Research Board, 2559*(1), 1–6.

National Safety Council. (2016). *Distracted driving public opinion poll*. Itasca, IL: National Safety Council.

Nees, M. (2018). Drivers' perceptions of functionality implied by terms used to describe automation in vehicles, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 62*(1), 1893–1897.

Omae, M., Hashimoto N, Sugamoto, T, & Shimizu, H. (2005). Measurement of driver's reaction time to failure of steering controller during automatic driving. *Review of Automotive Engineering, 26*, 213–215.

SAE International. (2018). *Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles* (SAE Standard J3016, Report No. J3016-201806). Warrendale, PA.

Schroeder, P., Wilbur, M., & Peña, R. (2018). *National survey on distracted driving attitudes and behaviors—2015* (Report No. DOT-HS-812-461). Washington, DC: National Highway Traffic Safety Administration.

Sullivan, J., Flannagan, M., Pradhan, A., & Bao, S. (2016). *Literature review of behavioral adaptations to advanced driver assistance systems*. Washington, DC: AAA Foundation for Traffic Safety.