How cars can help distracted drivers become better "highway citizens":

Design solutions for 5 of the top driving "pet peeves"

A Whitepaper by Kristin Anderson
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Whitepaper

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Whitepaper Overview

Most recent vehicle innovation seems to relate to preservation of the environment or the safety of the passengers of the vehicle. While these are critical goals for the vehicles of the 21st century, few companies are developing solutions to help make drivers what I call better "highway citizens". I coined the term highway citizen to refer to how a driver's behavior affects the overall driving ecosystem, similar to how companies tout what they do to make themselves good "corporate citizens" in the context of a business environment. It refers to not just the safety of other drivers, but even to something as granular as maintaining a general awareness of how their behavior contributes to another driver's mood. Things that would make someone a better highway citizen are those things that show that we consider other drivers as part of our driving behavior, rather than simply focusing on our individual, immediate needs.

This whitepaper presents a hypothesis of why people to fail as highway citizens: what are the fundamental causes, what are the behaviors we reasonably can hope to correct in the short term (driver distraction), and what sorts of behaviors need to be overcome as part of larger social and governmental initiatives (aggressive driving). Next, I explore some design solutions that might be used to help drivers recognize

      a) when they are exhibiting distracted behaviors, and
      b) when those behaviors are impacting others.

The hope is that drivers will be willing have their behaviors brought to their attention, and correct those behaviors so that they have a positive impact on the driving ecosystem – i.e. become better highway citizens.

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"Distractions are the cup holder of the 21st century: if your vehicle doesn't have them — and plenty of them — your next one will."

- Paul Atchley, Car Talk[1]

## What's Changed: Today's Driving Environment

A Shift in Landscape

The social landscape related to automobile use has changed dramatically over the past several decades. Once upon a time, cars were seen as a source of enjoyment before a mode of transportation. However, more families have either a single parent working multiple jobs or two working parents, and are commuting regularly. As a result, where use of the car was once a privilege for a teenager, or something the teenager had to work hard to buy, nowadays more teenagers are getting cars to support the family's busy lifestyle.

As a result of this increased teen car ownership, distracted driving is a problem that has been increasing. Portable technologies like cell phones, laptop computers, and music players are becoming fixtures in daily life. Automobile manufacturers provide connections for, or alternatives to, these devices – no longer are these conveniences a differentiating feature.

Additionally, modern life often seems to invite, even require, distraction. Many people take advantage of the ready availability of these devices in the car as an opportunity to make use of time spent driving to be more "productive", and justify it as a "necessity" of their busy lifestyle. Teenagers use their devices to keep in constant contact with peers, and the prevalence of distracted driving becomes obvious.

As number of people who need to drive regularly grows, congestion on the roads increases, and the effects of other drivers' inattention become more pronounced. Another increasingly serious problem is that of aggressive driving (AAA Foundation for Traffic Safety 2006). Although some individuals are naturally prone to aggression, the report indicated that everyone is at risk. Primed by an already stressful day, and compounded by the frustration of driving conditions, even those who are normally calm in most
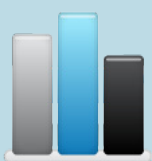
Between 1980 and 2003, lane-miles of highways increased 5 percent while vehicle miles of travel increased 89 percent.

- USDOT - Federal Highway Administration - 2006[2]

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"My greatest fear is that I'm going to be in a taxi when the driver gets a call from his wife that she's run off with his sexy cousin."
- Maureen Dowd,
Op-Ed Columnist, NYT[3]

What's Changed: Today's Driving Environment
(continued)

situations, can be susceptible to aggressive behavior on the roads.

The Challenge to Overcome

To clarify the scope of this exploration, there is likely no in-vehicle system that can be designed to change someone's stressful day at work or fundamentally change the attitude of a person who simply does not care how her actions affect others. Legislation to prevent distracted driving in the first place, as well vehicle innovations to keep drivers safe once accidents happen, are the tasks of institutions and not individuals like me. Where smart design decisions likely can have a significant impact on, however, are those small things that we could design into cars to overcome those behaviors of drivers that are purely caused by distraction and inattention, and prevent unnecessary frustration caused by other drivers. Thus the purpose of this whitepaper is to propose design solutions for 5 of the top driving "pet peeves" that drivers have, in a hopeful attempt to alleviate some of the day-to-day driving frustrations that poison the overall attitude of the "highway community".
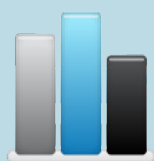
35% of drivers surveyed felt less safe on the road today than they did five years ago.

- 2009 Survey conducted by the AAA Foundation for Traffic Safety[4]

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"We need to develop a traffic safety culture that does not condone driving distracted like we have done with drunk driving."
- Vernon Betkey, Jr.
GHSA Chairman[5]

# What the Problem Is: Distracted Driving

The Root of the Problem

One of the biggest problems with distracted driving is that drivers often fail to consider distraction from inside or outside a vehicle as a serious problem.. While this seems a fairly universal phenomenon, the reasons for inattention vary by the type of driver. Examples include:

- **Younger drivers** think that they are invincible. They simply don't think of driving as a dangerous activity, and consider the social obligations of keeping in touch with friends their top priority. This leads to behaviors like texting while driving.
- **Experienced drivers** consider driving an automatic activity, and often focus more on the chaotic activity of day-to-day life: carpooling the kids to activities, rushing home for dinner, and coordinating the evening's schedule. Misplaced focus on more cognitively-demanding tasks leaves inadequate attention on driving when unexpected situations arise.

Related Research

Because of the potentially-high stakes of distracted driving, significant research has been conducted by cognitive scientists, human factors professionals, government safety analysts, and insurance companies. The key message from this research seems to be that "distracted driving is bad". While that research is useful, some of the most valuable research for explaining why this is so dangerous is the research related to general multitasking and more specific distracted-driving research that attempts to explore some of the deeper questions about why drivers choose to engage in distracting behaviors.

One study by Salvucci and Bogunovich (2010) explored how people reacted to an interruption during a cognitively demanding task that they had the opportunity to delay. The results of the study found that, when given the
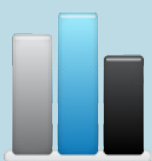
More than 80% of drivers admit to blatantly hazardous behavior: changing clothes, steering with a foot, painting nails and shaving.

- Nationwide Mutual Insurance Survey[6]

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"It's clear that distracted driving is definitely part of the cause in a large amount of accidents out there."

- Bill L. Windsor Jr.,
Nationwide Mutual Insurance[7]

What the Problem Is: Distracted Driving
(continued)

option, people will choose to delay the interruption until the cognitive load required by the primary task is complete. Although the tasks in this study were email (the high-cognitive load task) and Instant Messaging (IM) (the interruption), the study demonstrated that people will only multi-task during a cognitively-demanding task (one requiring focused attention) when forced to do so.

Horrey (2009) presented drivers with 4 distracting tasks to complete (make a call, read a text message, locate an address, and retrieve an item from the floor), but let them choose when to complete them. The goal of this study was to figure out whether drivers will wait to complete distracting tasks until they reach a less-demanding section road. In this case, drivers chose to engage in the distracting behaviors rather than to use their knowledge of the upcoming route to plan the best time to accomplish distracting tasks.

A third study by Leroy (2009) into general multitasking introduces the concept of "attention residue", which involves the cognitive artifacts from one task that linger in the brain after a person switches from one task to another task. The study essentially identified that how complete a person feels the first task is will essentially determine how effectively and immediately people will be able to switch tasks. The ways that findings that emerge from this study can impact driving are endless. Anything from a stressful day at work, to emotional call dropped because of poor cell coverage could linger and prevent focused attention on the task of driving.

The biggest culprit of distracted driving is still a driver's engagement in a cell phone conversation. Despite research clearly indicating that the unique nature of having a conversation on a cell phone focuses a person's attention to the internal conversation rather than the external environment (McCarley et al, 2004), drivers still believe that they can see the road, hear noises in and around the car, and have cognitive functions that are intact.
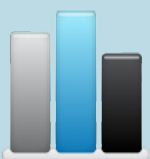
Drivers who use hand-held devices are four times as likely to get into crashes serious enough to injure themselves.

-Insurance Institute for Highway Safety[8]

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"New luxury options like GPS and touch screen interfaces for the radio should come secondary to fuel efficiency."

- Survey Respondant

What We Can Solve: The End Effects

Driving Attitudes and Behaviors Survey

As a regular commuter, I obviously have pet peeves of my own when driving an hour each way to and from work, but I wanted to avoid using my biased opinion on the "worst" driving faux pas when determining which problems are the most serious.

To get a reasonably reliable sample size, I sent a survey about driving attitudes and behaviors to approximately 70 friends, family, and coworkers. While the responses only represent a sample within a limited geographical area, the data from the 30 respondents seems consistent with the anecdotal pain points uncovered during my research, as well my own perceptions.

To get a richer picture of the general opinions and attitudes of people about driving, I also asked a number of questions about perceptions on vehicle innovation, what respondents feel are the obligations of the auto industry, the current state of the legal environment around vehicle safety, and their opinions on the effectiveness of enforcement of laws already in place.

The most relevant portion of the survey was a set of questions asking for the respondent's top pet peeves, ranked 1-5. Answers were requested via open text boxes. I avoided multiple choice questions to prevent biasing the answers by leaving out possible options that I might not think of, or ordering in a way that suggested ranking. From the 118 answers, with 28-30 answers per "rank" (only the 1st choice answer was required by the survey), I was able to consolidate the results into 15 unique pet peeves by combining similar answers into larger categories.

The 15 were:
- braking before signaling
- slowly edge closer to my bumper at a stop light
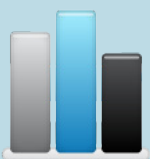
Despite the frustrations of commuting, 43% of survey respondants indicated that they still "enjoy taking trips that require driving" on the weekends.

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"[My pet peeve is] people who drift into other lanes when they are preoccupied with other things like cell phones, eating, etc."

- Survey Respondant

What We Can Solve: The End Effects
(continued)

- cutting corners at intersections
- cutting me off
- distracted driving (which included things like talking on a cell phone, texting, etc)
- driving too slowly in front of me
- failure to use turn signal appropriately
- honking
- inability to merge properly
- not going when light turns green
- reckless driving (which included things like excessive speeding, passing in the breakdown lane, drinking and driving)
- swerving lanes
- tailgating
- too much space between cars at a red light
- failure to stop and look for oncoming traffic before taking a "right on red" (what I call "right-of-way on red")

Insights from Discarded Answers

Despite instructions to answer based on the effect (ex. "swerving in my lane") not cause (ex. "talking on a cell phone"), the top answers were those that directly translated to "driving distracted" – for example, talking on a cell phone, putting on makeup, texting. While I did remove these from the ranked pet peeves for the sake of solution, I did dismiss to my initial inclination to disregard these answers altogether, since I felt it worth noting to reinforce the message that the problem is known to all, and needs attention.

However, I reiterate that this is not an attempt to solve the larger problem of distracted driving – I believe that it is the collective responsibility of government and the automotive industry to both educate on the dangers
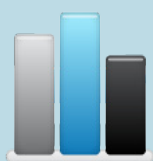
50% of survey respondants indicated distracted driving behaviors, including talking on a cell phone and texting, in their top 5 driving "pet peeves".

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"[My pet peeve is people who] show a general lack of any ability to drive."

- Survey Respondant

What We Can Solve: The End Effects
(continued)

of, and discourage against, distracted driving. This design exploration is merely an attempt to take a small step towards improving the overall driving environment by re-capturing a distracted drivers' attention, even if only long enough to prevent someone else from getting frustrated. While my recommendations would require buy-in from vehicle manufacturers to have included in dashboard design, they are relatively small interim steps, allowing the critical players to work on solving the larger problem of prevention.

Analyzing the Data: the top "Pet Peeves"

Admittedly, some of the answers are a bit more infrequent – my own personal "right-of-way on red" pet peeve only had a single supporter, for example. Others are in direct contradiction like "too much space between cars at a red light" and "slowly edge closer to my bumper at a stop light", so I chose to narrow my exploration down to coming up with solutions the top 5. To determine the top 5 responses, I counted the instances of each unique pet peeve according to rank, and weighted each answer according to the specific rank. A response listed as a"1st place" pet peeve was given a weighted value of 5, "2nd" given a value of 4, and so on.

The top 5 weighted responses were:

1. Driving too slowly in front of me
2. Cutting me off
3. Tailgating
4. Failure to use turn signal appropriately
5. Inability to merge properly

These 5 are the key driving behaviors that I attempt to overcome with tailored warnings in the context of a vehicle dashboard.
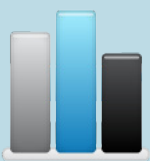
Among 30 survey respondants, the top 5 specific "pet peeves" are: 1. driving too slowly, 2. cutting others off, 3. tailgating, 4. failure to signal appropriately, and 5. inability to merge.

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How We Advance: Design Solutions

Guiding Assumptions

One important assumption to acknowledge is that I am making no effort to define how the necessary information will get to the car. With the emergence of "smart roads" like the one at the Virginia Technical Institute, organizations and individuals are already researching how roads can capture information from, and provide information to, "context-aware" vehicles (Sun, Wu, & Pan, 2009) on the road. I imagine that before any of my recommendations would be practical, there will already be technology in place for the road to tell the car what the speed limit is, for example. Even if it is not, cars can at least be designed in such a way that the car knows its speed relative to the acceleration of a car coming up from behind or pulling ahead, and can make educated estimations about when a driver is likely to be perceived as driving "too slow".

A second assumption is that these design solutions are intended purely to overcome behaviors that result directly from distraction. Many of the pet peeves described by the top 5 list have multiple potential causes, including aggression or recklessness. Because these behaviors are voluntary, no warning will convince these drivers to overcome the behavior. In fact, pointing out an aggressive driver's behavior only serves to further reinforce that behavior. However, distraction is something that most people acknowledge as dangerous. Thus, the unintentional nature of distracted-driving behaviors means that drivers are more likely to be willing to correct the behavior once they are aware of them. While any distracted behaviors could escalate to "dangerous" if extreme or prolonged, the scope of this exploration is to correct the behaviors while they are still at the "inconvenient for others" stage.
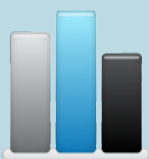
The future of VTTI's "Smart Road" includes local area wireless network for applications, such as automated highway systems, position location, data collection from sensors, and dynamic in-vehicle information systems.[9]

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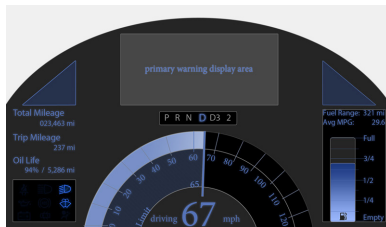How cars can help distracted drivers become better "highway citizens": Design solutions for 5 of the top driving "pet peeves"

"Machines lack the empathy required to consider how their actions impact those around them."

- Don Norman
The Design of Future Things[10]

Standard view of dashboard, including placement of warning area in the top-middle.
(See Appendix E for detail view)

How We Advance: Design Solutions
(continued)

Issues of Control

The first general decision I made about my design solutions is that my warnings would be purely informational. Many advanced systems on the market like Adaptive Cruise Control and Lane Departure detection actually empower the vehicle to overcome a driver's deficit by correcting the behavior directly. Such systems have potential to be exceptionally useful; however, the technology is not advanced enough to be foolproof yet. In his book *The Design of Future Things* (2009), Don Norman shares a number of stories of drivers whose cars exhibited unexpected outcomes during seemingly routine instances of behavior correction. Such outcomes are the result of cars simply not having the ability to reason like a human, and therefore not being able to anticipate all possible reasons why the logic might not as straightforward as programmed. As such, I have chosen to limit my recommendations to notifications, rather than allowing the vehicle to exert control.

Color Selection

My color selections were driven by 3 factors – perceptual and biological issues of optimal visibility, consideration for the relatively high numbers of people (males especially) who exhibit color blindness or decreased color sensitivity, and the emotional and psychological effects. It was important that the color selection did not inherently cause distraction, that it was accessible to the largest possible audience, and that the colors did not evoke emotions of anxiety or aggression.

Admittedly, blue is not the most visible color for the human eye. However, it serves the same purpose as blue links on a website: to exceed the "just noticeable difference" (jnd), defined as "the average detectable difference between two measureable qualities" (Strickland, 2001). Especially in the luminescent form that will appear on my dashboard, it provides adequate contrast with the charcoal gray or black backgrounds without appearing as such a jarring color that it diverts attention away from the primary goal of driving. Additionally, human peripheral vision is more sensitive to the color blue than to colors between red and green on the visible light spectrum due to uneven distribution of color-sensing cones in the eye (Wickens, Lee, Liu, & Gordon-Becker, 2004), thus making blue a better choice

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for displaying alerts that might need to recapture the attention of a driver looking at a passenger or at the controls on the radio, where vision will likely be indirect.

Given the need for a vehicle dashboard to be as universally visible as possible, I needed to make sure that the design did not exclude the nearly 10% of the male population afflicted with some sort of either red-green color sensitivity deficiency, or outright color-blindness (NCBI, 2009). While blue-yellow color blindness exists, it is far less common (less than .03% of the population). As such, this is one of the reasons I intentionally do not use any red in the design. For warnings that need differentiation from blue, I use an orange color.   In addition to being complementary to blue, thus providing adequate contrast for those who can see it as orange, it also will still appear distinctly different (as a sort of muddy yellow) even if the red tints in the orange are not visible (VisiCheck 2011).
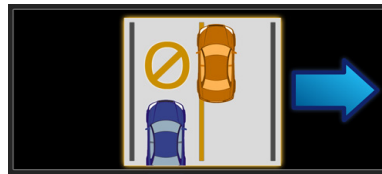
Original "blind-spot" dashboard warning

"Color-blind" simulation of "blind-spot" dashboard warning

Last consideration in the color selection process was the emotional and physiological effects of the possible range of colors. Anecdotally at least, red is known for causing increased blood pressure, and thus aggression. As such, in addition to the color-blindness consideration, red would be a poor choice in a situation with already-enormous potential for anxiety and aggression like driving. Conversely, the blue-purple color in use on the dashboard was among the "most pleasant" and "lease arousing" colors in one study on the effects of colors on emotions. Yellow-red (described in the dashboard interface as orange) was also among the least arousing, make it useful as a secondary color (Valdez, & Mehrabian, 1994), insuring that the visualization will not inherently draw attention without additional signals even when the driver is engaging in a distracted behavior.

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Warning Design General Principles

Beyond color selection, there were a number of considerations for the warning system to insure that distraction is minimized. Factors like placement, redundancy, escalating warnings, and supplemental information (for when the warnings themselves did not completely illustrate the behavior to be corrected) needed to be carefully designed into the system.

Placement: The placement of the visual warnings in the top-middle of the dashboard is intended to draw diverted attention back to a position where the driver's eyes can see the road, were they turned away.

Use of motion: While the warning is important, having the driver's attention on the task of driving is the top priority. As such, except in the most urgent of situations, the visual warning should not directly draw attention – it is merely conveniently accessible during the "safe" condition of watching the road, and redundant warnings alert the driver to the presence of the warning.

Redundancy: Each warning has not just a visual component, but an audible and haptic component as well. Because of the difficulty of human differentiation between signals in a recall tasks, rather than a recognition task, the audio warnings (a series of tones similar to the "door open" or "seat belt not buckled") and haptic warnings (vibrations of the driver's seat) are intended purely to alert the driver to the existence of a warning condition; they are not intended to indicate what the nature of the warning condition is – the visual warning will provide further detail for whenever it is safe for the driver to examine it.

Escalation: While the audible and haptic warnings are used consistently with all of the visual warnings, they vary relative to the immediate urgency of the warning. A more insistent set of warnings offer a second level of aggressive alerts, which manifest themselves as louder, more frequent audio tones, and stronger, more frequent haptic seat vibrations. Lastly, the visual warnings themselves also have a corresponding "urgent" form, where the instructions for behavior correction appear in the highly-visible (for most) yellow-green, and blink to capture maximum attention. For those color-blind individuals who cannot see the yellow-green, the brightness increases from the normal state so that differentiation is still possible.

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Supplemental Information: In addition to the audible and haptic warnings, the dashboard also contains supplemental information to support and elaborate on the message of some of the visual warnings.

Speedometer – The speedometer defaults to a subtle gradient of blue-purple hues when the driver is traveling within a reasonable margin of error above or below the speed limit (roughly +/- 10%). However, once outside of this reasonable margin, the speedometer indicates the amount above the speed limit, or the general speed (if driving too slowly) in varying shades from yellow to orange. While out of the scope of the warnings designed for this exploration, there would ultimately be a set of warnings specific to speed-related driving behaviors. This would support the warning intended to overcome the "driving too slow in front of someone" behavior".
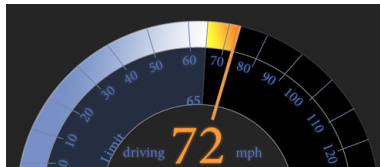
Speedometer indicating that the driver is going "***too fast***".
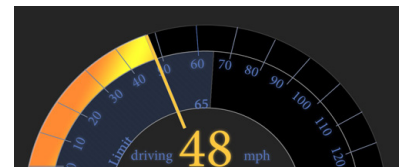
Speedometer indicating that the driver is going "***too slow***".

Blinker indicators – The blinker indicators on either side of the dashboard blink blue when the driver has intentionally turned on his or her directionals, and is making a turn or switching lanes. If, however, the driver seems to be switching lanes or taking a turn and has not turned on directionals, the blinker indicators blink orange at a higher frequency instead, indicating that there is a problem. This would support both the warning for lane departure, intended to correct both the "inability to use turn signals appropriately" behavior, and the "swerving lanes" behavior (not in the top 5, but still a frequent complaint).

Standard blinker "***on***" and "***off***" states (no error condition)

Warning blinker "***on***" and "***off***" states (failure to signal properly)

How We Advance: Design Solutions
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Pet Peeve:

Driving too slowly in front of me

Distraction Behavior:

The driver is driving too slowly in front of another car because she has failed to notice that a) her speed has decreased b) the speed limit has increased, or c) she has completed passing and should get back to the right.

Warning Trigger Conditions:

- Driving below the speed limit on a one-land road with a car behind.
- Driving at the same speed or slower than traffic to the right in the left-hand lane on a multi-lane road with a car behind.

Meaning of Warning:

Move to the right (or pull over) to let the car behind you pass.

Warning Variations:

- Solid right line on single-lane road.

To Get Rid of Warning:

- Obey on-screen instruction for correcting behavior.
- Increase speed to match safe flow of traffic.

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Pet Peeve:
Cutting me off

Distraction Behavior:
Driver is attempting to switch lanes without noticing that another car is in the way, most likely either due to failure to check blind spot, or failure to check mirrors at all.

Warning Trigger Conditions:
- Preparing to switch lanes (with or without using blinker) with a car in an unsafe proximity for the current speed of travel.

Meaning of Warning:
Oncoming car - stay in your lane.

Warning Variations:
- Car positions will vary based on the lane being switched into.
- Arrow will change to yellow-green, brighter, and blink to indicate greater urgency if behavior continues without correction.

To Get Rid of Warning:
- Obey on-screen instruction for correcting behavior.
- Accelerate to exceed speed of approaching car before switching lanes.

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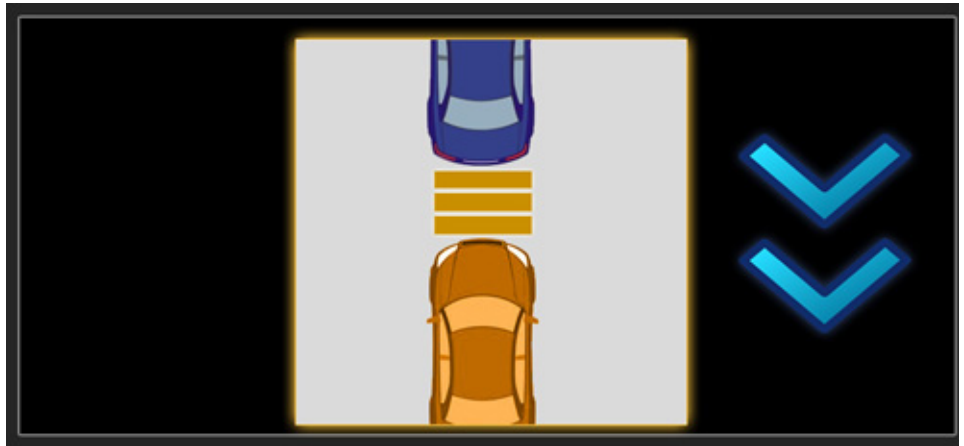
Pet Peeve:
Tailgating

Distraction Behavior:
Driver is not paying attention to the fact that the gap between her car and the car in front of her has decreased to less than 1 car-length per 10 MPH.

Warning Trigger Conditions:
- Driving faster than car in front and ended up driving too close.
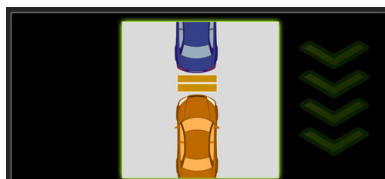- Car in front has decreased speed so that the gap is too small.

Meaning of Warning:
Driving too close, slow down to increase distance between cars.

Warning Variations:
- Warning has a more urgent version for instances where safety is a potential concern because of extremely small gaps between cars.

To Get Rid of Warning:
- Obey on-screen instruction for correcting behavior.
- Pass the front car if it is safe to so do.

"Urgent" tailgating warning - blinking "on" and "off" states

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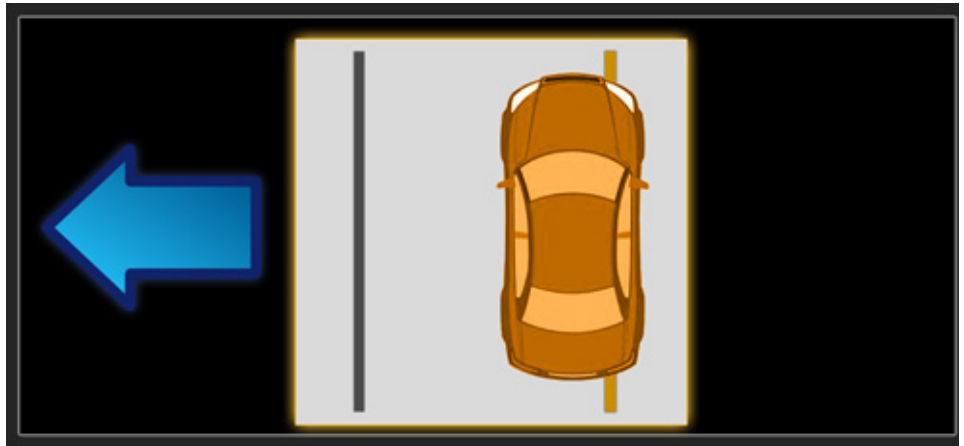
Pet Peeve:

Failure to use turn signal appropriately

Distraction Behavior:

Driver is attempting to switch lanes without properly using turn signals.

Warning Trigger Conditions:

- Crossing over a lane or road edge line without using turn signals.

Meaning of Warning:

You are out of your lane on the right side without signalling.

Warning Variations:

- Orange line indicating lane departure and direction of correction will vary based on the specific nature of the offence.

To Get Rid of Warning:

- Obey on-screen instruction for correcting behavior.
- Use turn signal to indicate an intentional lane change.

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Pet Peeve:

Inability to merge properly

Distraction Behavior:

While oftentimes difficulties merging can be the result of a distraction-behavior, this serves as more of an assistant for those who are less comfortable with the rules of merging.

Warning Trigger Conditions:

• Driver is not taking her proper turn in the merging process.

Meaning of Warning:

Need to change speed to merge properly.

Warning Variations:

• Depending on position and speed in the merging scenario, direction and instruction will vary.
• If merge is onto highway instead of combining lanes, graphic will vary.

To Get Rid of Warning:

• Obey on-screen instruction for correcting behavior.
• Use best judgment based on the behaviors of other drivers.

Turning Theory into Reality: Next Steps

Design Feedback

In an effort to get at least preliminary feedback on the effectiveness of the visual warnings, I dispatched a second survey to a group of friends, family, co-workers, and a Yahoo group of Bentley Human Factors in Information Design students and alumni. The survey presented each of my 5 initial designs for the warnings overcoming "pet peeves", without any indication of the purpose of the warning, and asked respondents to identify what behavior they thought was intended to portray and the method of correcting that behavior.

Of the 5, the most successful were those for "tailgating" and "lane departure", with 98% of respondents correctly identifying the purpose of the warning correctly, despite a complete lack of context. Other than global changes (noted later), I did not change either of these. The "merging assistant" showed 68% correct responses, and based on the fact that a) this one is an assistant, and b) the specific concerns identified by those with "wrong" answers would be answered by context, I chose not to make any changes to that one. The 2 most problematic were the "driving too slow" warning, with only 60% answering correctly, and the "blind spot" warning, with only 50% answering correctly.

I chose to focus my efforts on improving those for the next iterations, by implementing some of the more specific feedback offered by respondents. For the "driving too slow" warning, I ended up realizing that "someone wants to pass you" was really the intent, and I added line markers as suggested, including a dotted line to the right, to help indicate the fact that both cars were occupying the same lane, and that the car in back wanted to pass. For the "blind spot" warning, the biggest concerns I addressed were the confusion caused by the "X", which I replaced with the universal symbol for "no", and added the lane marker on the far side of the other car to help indicate that both cars were in adjacent lanes. Global changes recommended included not using the same arrow style for both "move left or right" and "speed up or slow down", so I revised the "move left or right" arrows to be solid rather than double-chevrons.

Turning Theory into Reality: Next Steps
(continued)

Outstanding Questions

While the initial feedback was extremely encouraging, and all implemented changes were suggested by a majority of respondents, the second iteration of warning designs would need additional testing before any of them should get built into any sort of high-fidelity prototype system. Furthermore, there is a significant amount of work that still needs to be done before the system as a whole would be ready for production, particularly in terms of the non-visual warnings.

There have been a number of relevant studies done surrounding the practical implementations of visual, audible, and haptic in-vehicle warning systems, exploring everything from the best types of tones for audible alerts (Shahab, Terken, & Eggen, 2010), to the best timing for escalating warnings (Lee, Hoffman, & Hayes, 2004), to whether or not vocal prompts are more effective than abstract tones (Ho, & Spence, 2005) , to how to combine haptic and audible alerts most effectively (Lee, Hoffman, & Hayes, 2004; Cao, Van der Sluis, Theune, Op den Akker , & Nijholt, 2010), and how to combine audible and visual alerts most effectively (Lee, Gore, & Campbell, 1999), or combinations of most (or all) of these (Eby, Molnar, Kostyniuk, Shope, & Miller, 2004; Campbell, Richard, Brown, & McCallum, 2007). These studies, and others like them, can be used to lay the groundwork for defining how the system will collaborate to help drivers overcome distraction.

Once those factors have been identified and refined in theory, then begins the complication of putting the system into practice. In addition to the current limitations of the environment passing the information to the vehicle needed to trigger the warnings, the practicality of the system needs extensive testing in near-real-world settings.

Questions still to be answered include:

Will the system work for single-use situations like rental cars, or will the learning from the repeated use that will inevitably come from ownership be necessary?

Will the accuracy of the triggers be sufficient for the driver to correctly respond, or will the system suffer from false positive warnings or failure to

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Turning Theory into Reality: Next Steps
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present warnings when needed?

Will audible and haptic warnings cause cognitive overload?

Will warnings get ignored as drivers grow overly accustomed to them?

Will drivers actually be willing to change behaviors that are not inherently endangering themselves or others?

Despite the seemingly daunting nature of the outstanding questions, I feel that the visual designs presented here provide a solid foundation for further exploration. While the majority of vehicle innovation continues to revolve around important issues like safety and fuel economy, it is critical that someone is at least considering the impact that driving distraction has on other drivers even in something as simple as inconvenience. By providing a means for drivers to self-correct, and possibly avoid inconveniencing another driver, hopefully we can begin to reduce the instances of frustration leading to aggressive driving, and eventually road rage.

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Appendix A: Citations

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Appendix A: Citations
(continued)

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Appendices

Appendix B: Quotes and Statistics

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Appendices

Appendix C: "Driving Behaviors" Survey

1. How long is your commute to work? *required
- <15 minutes
- 15-30 minutes
- 30-45 minutes
- 45-60 minutes
- >1 hour

2. What type of vehicle do you drive? *required
- Coupe/Sedan
- SUV
- Mini-van
- Truck
- Other (indicate what)

3. Indicate how much you agree with this statement: I enjoy my commute *required
- Strongly disagree
- Moderately disagree
- Slightly disagree
- Neutral
- Slightly agree
- Moderately agree
- Strongly agree
- Not Applicable

4. Indicate how much you agree with this statement: I often get frustrated with my commute *required
- Strongly disagree
- Moderately disagree
- Slightly disagree
- Neutral
- Slightly agree
- Moderately agree
- Strongly agree
- Not Applicable

5. Indicate how much you agree with this statement: Automobile manufacturers have a an obligation to safety beyond what is legally mandated
- Strongly disagree
- Moderately disagree
- Slightly disagree
- Neutral
- Slightly agree
- Moderately agree
- Strongly agree
- Not Applicable

6. Please pick the one that answers BEST.

On the weekend, I: *required
- drive only when necessary
- let my spouse/significant other do the driving
- enjoy taking trips that require driving
- drive as a source of relaxation
- other (indicate what)

7. Indicate the top 5 things that other drivers do that bother you, starting from worst pet peeve. *Note: Please answer based on the effects (ie. cutting me off), not causes (ie. talking on a cell phone). *required

8. What are your general thoughts about innovation in the automobile industry?

9. What are your general thoughts about the legal system with regard to driver safety?

10. What are your general thoughts about enforcement of current driving laws?

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Appendices

Appendix D: Original Designs/Feedback

Survey Introduction

"The images presented here are potential design solutions for in-vehicle warnings. Assume that you as the driver already know 3 items before receiving the warning:
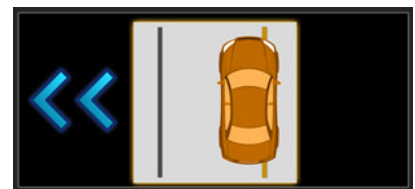
* The orange car is always your car
* The warning demonstrates a current driving behavior that needs to be corrected
* The warning give guidance on how to correct the behavior

Given that knowledge, please indicate what you think the warning means for each warning image."

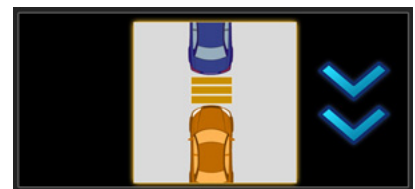## Original Survey Images (plus result based on feedback)
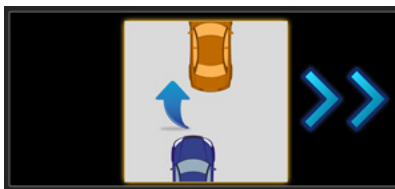

"blind spot" (changed)

"lane departure" (minor change)

"merging assistant" (no change)

"tailgating" (no change)

"driving too slow" (changed)

Follow-up Questions

"Below are the 5 images you already reviewed, coupled with the actual intent of the warning. If you choose, feel free to provide feedback on how these images could more clearly convey the intended message. Again, all questions below are optional."

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Appendix E: Enlarged Dashboard