Main Instructions (Simulator Experiment 1)

Before you drive in our driving simulator today, we would like you to listen to these instructions. After you’ve heard them, we will answer any questions you have. Then, we will ask you to take a series of short drives in simulated conditions of poor visibility.

This study is part of a series in which we are assessing new automobile technologies. These technologies aim to help drivers by providing useful information and warnings. The study is part of the Trunk Highway 7 Project, which has the overall objective of increasing safety on Highway 7 between Minneapolis and Hutchinson.

We are particularly concerned with driving in bad weather, or poor visibility conditions, when it is difficult to see the road markings & when it is hard to see other vehicles ahead—particularly those that are parked or have been abandoned.

Recently, new technologies have been developed that make it is possible—even in bad weather—to pick up lane markings and locate vehicles and other objects ahead of the driver. We will display this information to the driver. What we want to do in this experiment is to find out whether drivers can use this kind of information, and we want to determine whether it makes it easier for them to drive in poor visibility conditions.

This car has been equipped with a head-up display. The display will show you where the road is and where any vehicles ahead might be—so that, even when the visibility is poor and it is difficult to see the lane markings or other vehicles, you will still be able to drive.

On the display you will see two things. First, you will see the edge- and center-line markings of the road ahead. These projected markings will overlay the actual edge- and center-lines on the road ahead. And second, if there is another vehicle ahead of you, that is within 350 ft, you will see a rectangular outline that highlights the actual vehicle on the road.

As well as continuously showing the road and letting you know about other vehicles, the head-up display may also give you two kinds of warnings—they are lane departure warnings and collision avoidance warnings. You may see a lane departure warning, if you are going out of lane, without meaning to. And you
may see a collision avoidance warning if there is a vehicle ahead that is stationary or going so slow that you could run into it. In this experiment, we are testing different ways of giving you these warnings. As I already mentioned, when you are in the simulator, you will drive several times—and before each drive, I will tell about the warnings and how they will be presented to you. But, first, do you have any questions?
Instructions for Specific Trials (Simulator Experiment 1)

None & None

For this drive, there will be no lane departure warnings. And no collision avoidance warnings.

None & Red Only

For this drive, there will be no lane departure warnings.

But, you will be given a collision avoidance warning—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. When you get very close to that vehicle, you will receive the warning. The outline of the vehicle ahead will change color—it will change to red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

None & Yellow & Red

For this drive, there will be no lane departure warnings.

But, you will be given a collision avoidance warning and an advisory—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it.

The advisory will come first. When you are getting close to the vehicle ahead, the outline of that vehicle will change color—it will change to yellow. If you get this yellow advisory, you should be ready to take appropriate action.

You will continue traveling toward the vehicle ahead and, when you are very close, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color again—this time it will go red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

Red Area & None

For this drive, you will be given a lane departure warning if you start to go out of lane.

You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, the area next to that lane marker will change color—it will change to red. And, if you get this red area warning, you should steer back into lane.

For this drive, there will be no collision avoidance warnings.

Red Area & Red Only
For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, the area next to that lane marker will change color—it will change to red. If you get this red area warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. When you get very close to the vehicle ahead, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color—it will change to red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

**Red Area & Yellow and Red**

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, the area next to that lane marker will change color—it will change to red. If you get this red area warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning and an advisory—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it.

The advisory will come first. When you are getting close to the vehicle ahead, the outline of that vehicle will change color—it will change to yellow. If you get this yellow advisory, you should be ready to take appropriate action.

You will continue traveling toward the vehicle ahead and, when you are very close, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color again—this time it will go red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

**Area & None**

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, the area next to that lane marker will be shaded—it will be shaded the same color as the lane marker. If you get this shaded area warning, you should steer back into lane.

For this drive, there will be no collision avoidance warnings.

**Area & Red Only**
For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, the area next to that lane marker will be shaded—it will be shaded the same color as the lane marker. If you get this shaded area warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. When you get very close to the vehicle ahead, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color—it will change to red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

**Area & Yellow and Red**

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, the area next to that lane marker will be shaded—it will be shaded the same color as the lane marker. If you get this shaded area warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning and an advisory—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it.

The advisory will come first. When you are getting close to the vehicle ahead, the outline of that vehicle will change color—it will change to yellow. If you get this yellow advisory, you should be ready to take appropriate action.

You will continue traveling toward the vehicle ahead and, when you are very close, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color again—this time it will go red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

**Red Line & None**

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, that lane marker will change color—it will change to red. If you get this red marker warning, you should steer back into lane.

For this drive, there will be no collision avoidance warnings.
Red Line & Red Only

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, that lane marker will change color—it will change to red. If you get this red marker warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. When you get very close to the vehicle ahead, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color—it will change to red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

Red Line & Yellow & Red

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch the lane marker, that lane marker will change color—it will change to red. If you get this red marker warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning and an advisory—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. The advisory will come first. When you are getting close to the vehicle ahead, the outline of that vehicle will change color—it will change to yellow. If you get this yellow advisory, you should be ready to take appropriate action.

You will continue traveling toward the vehicle ahead and, when you are very close, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color again—this time it will go red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

Double Line & None

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch a lane marker, that lane marker will change—it will change to a double line. If you get this double-line warning, you should steer back into lane.

For this drive, there will be no collision avoidance warnings.
Double Line & Red Only

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch a lane marker, that lane marker will change—it will change to a double line. If you get this double-line warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. When you get very close to the vehicle ahead, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color—it will change to red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

Double Line & Yellow & Red

For this drive, you will be given a lane departure warning if you start to go out of lane. You will be given the warning if your front wheel touches the lane marker, either to the left or right. If your wheel does touch a lane marker, that lane marker will change—it will change to a double line. If you get this double-line warning, you should steer back into lane.

Also for this drive, you will be given a collision avoidance warning and an advisory—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it.

The advisory will come first. When you are getting close to the vehicle ahead, the outline of that vehicle will change color—it will change to yellow. If you get this yellow advisory, you should be ready to take appropriate action.

You will continue traveling toward the vehicle ahead and, when you are very close, you will receive a collision avoidance warning. The outline of the vehicle ahead will change color again—this time it will go red. If you get a red collision avoidance warning you should take appropriate action—either slowing down or steering around the vehicle.

Main Instructions (Simulator Experiment 2)

Before you drive in the driving simulator today, we would like you to listen to these instructions. After you’ve heard them, we will answer any questions you have. Then, we will ask you to take a series of short drives in which there will be simulated snow cover and poor visibility.
This study is part of a series in which we are assessing new automobile technologies. These technologies aim to help drivers by providing useful information and warnings. The study is part of the Trunk Highway 7 Project, which has the overall objective of increasing safety on Highway 7 between Minneapolis and Hutchinson.

We are particularly concerned with driving in bad weather, when it is very difficult—sometimes impossible—to see the road markings, & when it is hard to see other vehicles ahead—particularly those that are parked or have been abandoned.

Recently, new technologies have been developed that make it possible—even in very bad weather—to pick up lane markings and locate vehicles and other objects ahead of the driver. What we want to do in this experiment is to find out whether you as drivers can use this kind of information, and we want to determine whether it makes it easier for you to drive in poor visibility conditions.

This car has been equipped with a head-up display. There is a head-up display in front of you. It will show you where the road is and where any vehicles ahead might be—so that, even when the visibility is very bad and it is difficult to see the lane markings or other vehicles, you will still be able to drive.

On the display you will see two things. First, you will see the edge- and center-line markings of the road ahead. These projected markings will overlay the actual edge- and center-lines on the road ahead. And second, if there is another vehicle ahead of you—that is within 350 ft—you will see a rectangular outline that highlights the actual vehicle on the road.

The head-up display will also give you collision avoidance warnings. You will see a collision avoidance warning—if there is a vehicle ahead of you that is stationary, or going so slowly that you could run into it. When you get very close to that vehicle, you will receive the warning. The outline of the vehicle ahead will change color—it will change to red. If you get a red collision avoidance warning you should take appropriate action—either by slowing down or by steering around the vehicle.

So, the head up display will continuously show you the road and let you know about other vehicles, and will give you collision avoidance warnings.

Also, in some drives you will be given a lane departure warning, if you are going out of lane, without meaning to. We are testing different ways of giving this warning. It may be given to you on the head-up display. In this case the lane marker on the HUD will change color—it will change to red. Or you may hear the sound of a rumble strip. Or you may feel a vibration like a rumble strip in the side of the driver’s seat. Or you may get some combination of these warnings. Today, you will drive several times—and before each drive, I will tell how the lane departure warning will be given to you.
Specific Instructions (Simulator Experiment 2)

**Visual/Red Line**

For this drive, if you start to go out of lane, you will be given lane departure warnings that you see on the head-up display. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then on the HUD a lane marker will change color—it will change to red. If you are going out of lane to the right, the warning will be given on the right; and if you are going out of lane to the left, the warning will be given on the left. If you see a red marker warning, you should steer back into lane.

**Auditory/Rumble Sound**

For this drive, if you start to go out of lane, you will be given lane departure warnings that you hear. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then you will hear a warning—it will sound as if you are going over a rumble strip. If you are going out of lane to the right, the three warnings will be given on the right; and if you are going out of lane to the left, the three warnings will be given on the left. If you hear a rumble-strip warning, you should steer back into lane.

**Active seat**

For this drive, if you start to go out of lane, you will be given lane departure warnings that you feel in the driving seat. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then you will feel a warning in the driver’s seat—there will be a vibration that feels like going over a rumble strip. If you are going out of lane to the right, the warning will be given on the right; and if you are going out of lane to the left, the warnings will be given on the left. If you feel a rumble-strip warning, you should steer back into lane.

**Visual/Red Line & Auditory/Rumble Sound**

For this drive, if you start to go out of lane, you will be given lane departure warnings in two ways—you will see and hear the warnings. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then on the HUD a lane marker will change color—it will change to red. At the same time, you will hear a warning—it will sound as if you are going over a rumble strip. If you are going out of lane to the right, the two warnings will be given on the right; and if you are going out of lane to the left, the three warnings will be given on the left. If you see a red marker warning or hear a rumble-strip warning, you should steer back into lane.
Auditory/Rumble Sound & (Haptic) Driving Seat

For this drive, if you start to go out of lane, you will be given lane departure warnings in two ways—you will hear and feel the warnings. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then you will hear a warning—it will sound as if you are going over a rumble strip. At the same time, you will feel a warning in the driver’s seat—there will be a vibration that feels like going over a rumble strip. If you are going out of lane to the right, the two warnings will be given on the right; and if you are going out of lane to the left, the two warnings will be given on the left. If you hear a rumble-strip warning or feel a rumble-strip warning, you should steer back into lane.

(Haptic) Driving Seat & Visual/Red Line

For this drive, if you start to go out of lane, you will be given lane departure warnings in two ways—you will hear and feel the warnings. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then you will feel a warning in the driver’s seat—there will be a vibration that feels like going over a rumble strip. At the same time, on the HUD a lane marker will change color—it will change to red. If you are going out of lane to the right, the two warnings will be given on the right; and if you are going out of lane to the left, the two warnings will be given on the left. If you feel a rumble-strip warning, or see a red marker warning, you should steer back into lane.

Visual/Red Line & Auditory/Rumble Sound & (Haptic) Driving Seat

For this drive, if you start to go out of lane, you will be given lane departure warnings in three ways—you will see, and hear, and feel the warnings. You will be given a warning if your front wheel touches a lane marker. If your wheel does touch a lane marker, then on the HUD a lane marker will change color—it will change to red. At the same time, you will hear a warning—it will sound as if you are going over a rumble strip. And you will feel a warning in the driver’s seat—there will be a vibration that feels like going over a rumble strip. If you are going out of lane to the right, the three warnings will be given on the right; and if you are going out of lane to the left, the three warnings will be given on the left. If you see a red marker warning, or hear a rumble-strip warning, or feel a rumble-strip warning, you should steer back into lane.
Questionnaire Form Single Modality (Experiment 2)

Questions

The following questions deal with your experience of driving in the simulator today. Each question is followed by a scale. This scale allows for a range of possible answers—from extremely favorable to extremely unfavorable. For each question, we would like you to make a mark on the scale in the place that best indicates how you feel about that question.

For example: If you were asked, “how would you rate the importance of air bags in driver safety?” you might answer as shown below—

Your answer

<table>
<thead>
<tr>
<th>Completely Unnecessary</th>
<th>Absolutely necessary</th>
</tr>
</thead>
</table>

There are two sets of questions. The first set deals with the head-up display—but not with the lane departure warnings. And the second set will deal with lane departure warnings.

Below you will find a set of four questions about the usefulness of the head-up display and the information it provided you today.

1. When you drove in poor visibility conditions today, how useful were the simulated lane markings provided by the head-up display?

<table>
<thead>
<tr>
<th>Not at all useful</th>
<th>Very useful</th>
</tr>
</thead>
</table>
2. When you drove in poor visibility conditions today, how useful was it for the head-up display to let you know that there were vehicles ahead?

Not at all useful                              Very useful

3. When you drove in poor visibility conditions today, how useful were the collision avoidance warnings provided by the head-up display?

Not at all useful                              Very useful

4. How easy was it for you to drive in the poor visibility conditions you experienced in the simulator while you were using the head-up display?

Very difficult                              Very easy

The following questions deal with lane departure warnings.

5. When you drove in poor visibility conditions today, how useful were the lane departure warnings?

Not at all useful                              Very useful
6. When you drove in poor visibility conditions today, how useful was the red line (on the head-up display) for letting you know you were out of lane?

Not at all useful                                    Very useful

7. When you drove in poor visibility conditions today, how useful was the rumble-strip sound for letting you know you were out of lane?

Not at all useful                                    Very useful

8. When you drove in poor visibility conditions today, how useful was the vibration (in the driver's seat) for letting you know you were out of lane?

Not at all useful                                    Very useful

9. When you drove in poor visibility conditions today, how useful were the red line (on the head-up display) and rumble strip sound and vibration (in the driver's seat) for letting you know you were out of lane?

Not at all useful                                    Very useful
Finally do you have any comments about your experience of driving in the simulator today?
Questionnaire Form Dual Modality (Experiment 2)

Questions

The following questions deal with your experience of driving in the simulator today. Each question is followed by a scale. This scale allows for a range of possible answers—from extremely favorable to extremely unfavorable. For each question, we would like you to make a mark on the scale in the place that best indicates how you feel about that question.

For example: If you were asked, “How would you rate the importance of air bags in driver safety?” you might answer as shown below—

Your answer

| Completely unnecessary | Absolutely necessary |

There are two sets of questions. The first set deals with the head-up display—but not with the lane departure warnings. And the second set will deal with lane departure warnings.

Below you will find a set of four questions about the usefulness of the head-up display and the information it provided you today.

5. When you drove in poor visibility conditions today, how useful were the simulated lane markings provided by the head-up display?

| Not at all useful | Very useful |
6. When you drove in poor visibility conditions today, how useful was it for the head-up display to let you know that there were vehicles ahead?

Not at all useful                                   Very useful

7. When you drove in poor visibility conditions today, how useful were the collision avoidance warnings provided by the head-up display?

Not at all useful                                   Very useful

8. How easy was it for you to drive in the poor visibility conditions you experienced in the simulator while you were using the head-up display?

Very difficult                                      Very easy
The following two questions deal with lane departure warnings.

5. When you drove in poor visibility conditions today, how useful were the lane departure warnings?

Not at all useful  Very useful

Finally, do you have any comments about your experience of driving in the simulator today?