

# **AV Communication Strategies Modeled in VR: Perceptions of Pedestrians, Bicyclists, and Human Drivers**

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# Objectives

- About 50% of respondents from the United States intend to use AVs.
- Improved AV communication has been linked with increased trust and acceptance of the new technology.
- We need to develop one **simple, uniform language**.

# Objectives

Perceptions

&

Behavior



# Perceptions

Understanding

Comfort

Trust

Acceptance







# Methodology

47 pedestrian participants; within-subject experimental design

15' x 8' VR area; wireless headset





# Methodology

## HTC Vive and Unreal Engine 4

Hit B to bring up button

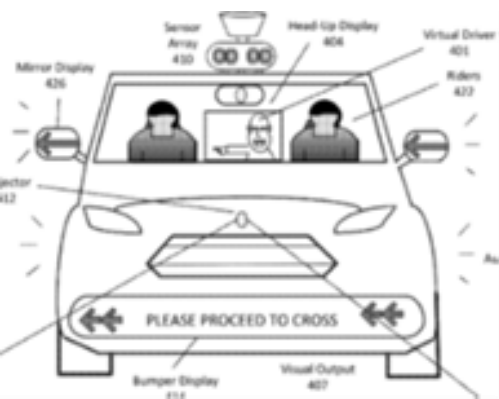
Car Parts:

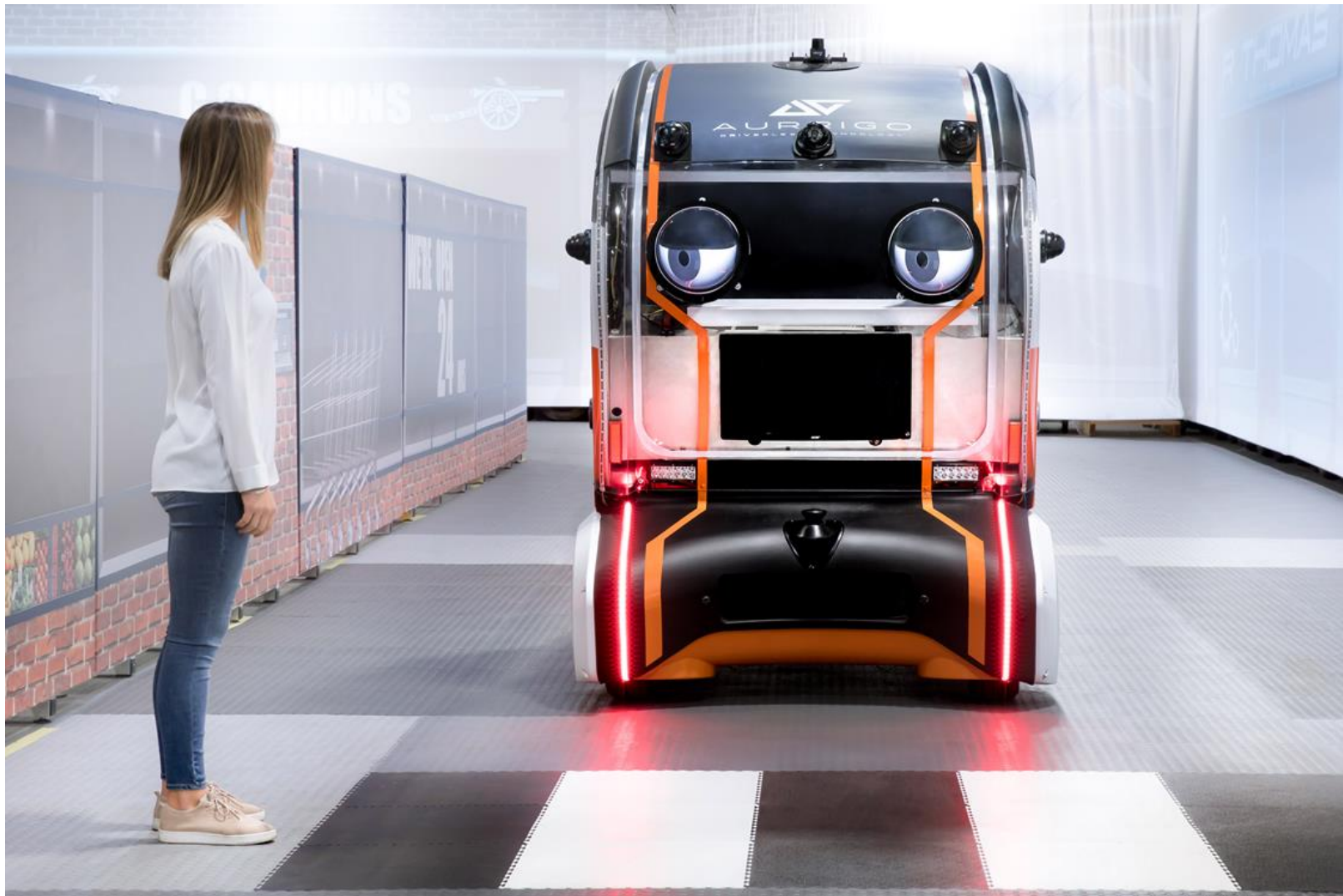
- Key 1 Grill: **Visible**
- Key 2 IntRoof: **Visible**
- Key 3 Mirrors: **Visible**
- Key 4 Car Top: **Visible**

Car Passes Through: **False**  
(Toggle Key P)

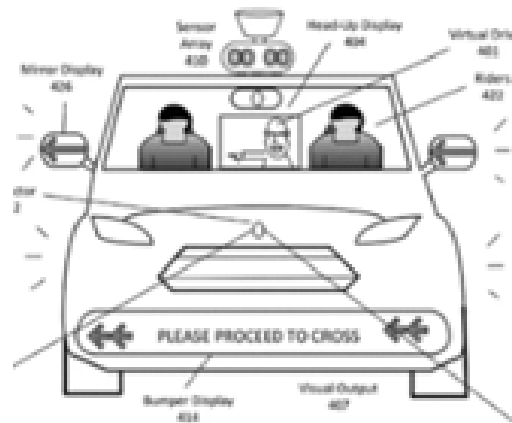








# Text Grille





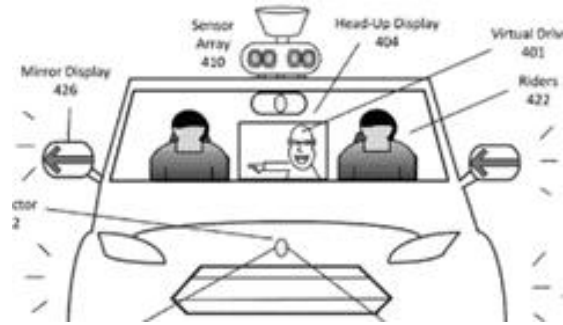
# Text Roof



# LED Windshield



# Side Mirror Arrows





# Door Display



# Results

Responses were higher with an eHMI.

Largest increase was for Q3, smallest was for Q7.

Females reported higher scores than males, but male scores increased more with the presence of an eHMI.

	With eHMI			Without eHMI				Difference		
	Male n=57	Female n=45	Total n=102	Male n=7	Female n=9	Total n=16		Male	Female	Total
Q1 Understand	3.93	4.22	4.06	3.14	4.22	3.75		0.79	0.00	0.31
Q2 How quickly	3.72	3.78	3.75	2.71	3.78	3.31		1.01	0.00	0.44
Q3 Interface v. Speed	3.21	3.13	3.18	1.71	2.00	1.88		1.50	1.13	1.30
Q4 Right-of-way	4.14	4.51	4.30	3.57	4.50	4.07		0.57	0.01	0.23
Q5 Comfort	4.12	4.29	4.20	3.29	4.22	3.81		0.83	0.07	0.39
Q6 Trust	3.81	4.18	3.97	2.71	3.89	3.38		1.10	0.29	0.59
Q7 Acceptance	3.51	3.29	3.41	3.29	3.33	3.31		0.22	-0.04	0.10
Overall Average	3.78	3.91	3.84	2.92	3.71	3.36		0.86	0.21	0.48

Survey responses for presence vs. non-presence of eHMI when AV yielded by gender

For females, males, and total participants, responses were ordered:

1. Text on the grille
2. Text on the roof
3. Side mirror arrows
4. LED windshield

Interestingly, the LED windshield had the highest scores for acceptance for both genders, although the LED windshield ranked lowest for all other questions.

	Text Grille			LED Windshield			Side Mirror Arrow			Text Roof		
	M n=14	F n=15	T n=29	M n=9	F n=8	T n=17	M n=19	F n=10	T n=29	M n=15	F n=12	T n=27
Q1 Understand	4.57	4.73	<b>4.66</b>	3.33	3.38	<b>3.35</b>	3.74	4.00	<b>3.83</b>	3.93	4.33	<b>4.11</b>
Q2 How quickly	4.21	4.27	<b>4.24</b>	3.33	3.00	<b>3.18</b>	3.42	3.60	<b>3.48</b>	3.87	3.83	<b>3.85</b>
Q3 Interface v. Speed	3.71	2.93	<b>3.31</b>	2.44	2.75	<b>2.59</b>	3.16	3.30	<b>3.21</b>	3.27	3.50	<b>3.37</b>
Q4 Right-of-way	4.64	4.73	<b>4.69</b>	3.33	4.13	<b>3.71</b>	4.16	4.40	<b>4.24</b>	4.13	4.58	<b>4.33</b>
Q5 Comfort	4.64	4.53	<b>4.59</b>	3.44	3.88	<b>3.65</b>	4.00	4.30	<b>4.10</b>	4.20	4.25	<b>4.22</b>
Q6 Trust	4.07	4.27	<b>4.17</b>	3.00	3.88	<b>3.41</b>	3.79	4.20	<b>3.93</b>	4.07	4.25	<b>4.15</b>
Q7 Acceptance	3.79	3.27	<b>3.52</b>	4.00	3.50	<b>3.76</b>	3.47	3.20	<b>3.38</b>	3.00	3.25	<b>3.11</b>
Overall Average	4.23	4.10	<b>4.17</b>	3.27	3.50	<b>3.38</b>	3.68	3.86	<b>3.74</b>	3.78	4.00	<b>3.88</b>

Responses for eHMIs when AV yielded by gender



# Conclusions

- The presence of an eHMI improved pedestrian participants' perceptions of AVs.
- Although females generally reported higher scores, males had larger improvements in perceptions with the introduction of an eHMI.
- While eHMI introduction impacted genders differently, both genders agreed that text eHMIs outperformed non-textual interfaces, with the text grille eHMI receiving the highest scores.
- Understanding, trust, and comfort followed a similar pattern (large responses to the presence of an eHMI and best outcomes with text displays), but acceptance did not (a small response to the presence of an eHMI and best outcomes with LED windshield).

# Conclusions

- Drivers preferred interfaces on the side of the vehicle
- Pedestrians and Bicyclists preferred text on the front

## Pedestrian



## Driver



# Conclusions

- Participants reported learning after two trials. After learning, they preferred simpler interfaces. This would help legibility issues inherent with text.

# Conclusions

- How do we overcome issues inherent with text displays, such as legibility, perception times, and language barriers?
- What role does the size of the interface play in perception outcomes?
- What learning curve is present, and how will this impact the future of AV-pedestrian interactions? As people become accustomed to AVs, might simple lights similar to existing brake lights or turn signals become more acceptable?
- What role might color, sequence, time of day, and weather conditions play in pedestrian perceptions?
- Are text displays still preferred when there are ten AVs simultaneously approaching a busy intersection?



**Thank You!**

**Questions?**

