

# REDUNDANT HEAD-UP AND HEAD-DOWN DISPLAY CONFIGURATIONS AND DISTRACTION DUE TO COMMON SECONDARY AUTOMOBILE TASKS.

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OPTIVe (OPTimized system  
integration for safe interaction in  
Vehicles)



Volvo Car Corporation

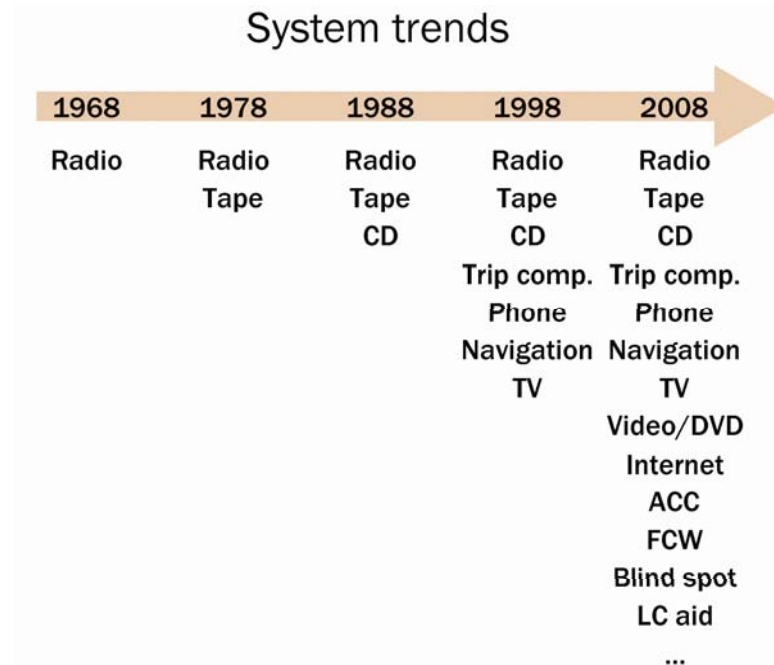


IVSS – In Vehicle Safety Systems

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Background

# More and more systems in vehicles



## Distraction from systems in the automobile interior

### Background

- Higher amount of information presented
- Dynamic displays showing many types of information in one place
- Driver is mainly guided by vision
- Visual distracters compete with the same perceptual and cognitive resources as driving
- Visual information can be lost in the quantity of information

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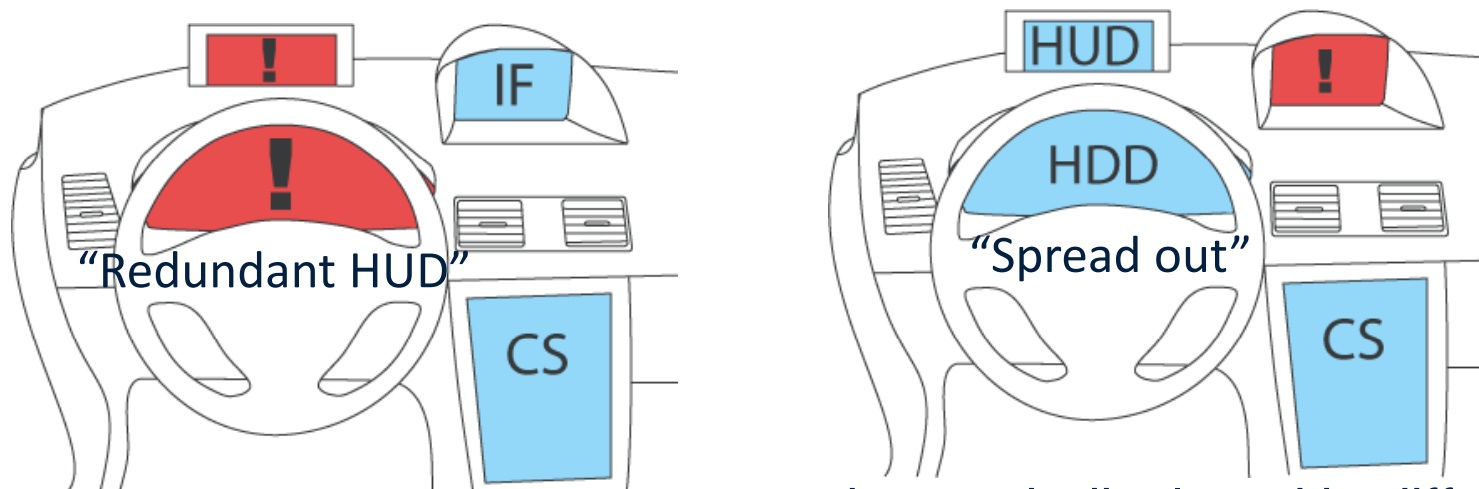
## Background

If information is acquired from a display located close to the road view, e. g. a Head-Up Display (HUD), the driving performance is less degraded than for a distant display

= eyes-on-the-road and hands-on-the-wheel

## Comparison of two display configurations

- Redundantly displayed information in driver's line of sight compared to spread out information: Driving performance? Added distraction? Time spent looking away from the road?
- Driver's stress level affected by information in line of sight?



- only driving and driving with a secondary task displayed in different positions

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## Research questions & Conditions

# Driving simulator study with physiological measuring and eye-tracking

18 drivers

(8 females and 10 males, 24 to 60 years.  $M=37.8$  years)



LTU DesignLab Driving simulator

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## Method

Driving  
performance

Can be direct measure of traffic safety  
i.e. lane exceedences

Eye-tracking

Indirect measure of traffic safety  
i.e. inattention that could degrade driving

Physiological  
measures

Indirect measure of traffic safety  
i.e. inattention that could degrade driving

Interviews

Why did we get the results we got?

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## Method - Measures



## As realistic driving environment as possible

15km road, 2 lanes, rural areas

Short segment, 4 lanes, urban environment

50km/h / 70km/h

Oncoming traffic in other lane, some traffic in same lane to be overtaken or that made unexpected manoeuvres



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## Method

- Mann-Whitney's U-test - between subject
  - Wilcoxon Signed Ranks Test - within subjects
  - Significance levels .05.
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Differences between:  
driving tasks for "Redundant HUD"  
driving tasks for "Spread out"  
display configurations for "driving only"  
display configurations for "driving & task"

"Redundant HUD" "driving only"	"Spread out" "driving only"	between subjects
"Redundant HUD" "task"	"Spread out" "task"	
within subjects		

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## Method

## Messages and placements

Nr	Placement	Message
1	Infotainment	Raise temperature to 22°C
2	Centerstack	Activate CD
3	Head-down display	Change to CD track 5
4	Infotainment	Lower volume to lowest perceptible
5	Head-up display	Activate MP3
6	Head-down display	Change to album “French pop”
7	Infotainment	Raise volume two steps
8	Head-up display	Dial 070-3679324
9	Head-down display	Raise fan speed two steps
10	Centerstack	Dial 070-6862584

*Note: Messages translated from Swedish to English*

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## Method - Tasks

- Messages in “Redundant HUD” are:
  - Noticed faster
  - Looked upon more frequent
  - HUD is preferred over HDD
  - Less lane deviation
- No physiological differences

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## Results

### **“driving with task” compared to “driving only” for “Redundant HUD”**

- Less speed deviation (z=-2.521, p=0.012)
  - Less deviation from the speed limit (z=-2.521, p=0.012)
  - Time spent looking away from road significantly increased (z=-2.380, p=0.017)
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### **“driving with task” compared to “driving only” for “Spread out”**

- Higher mean speed (z=-1.988, p=0.047)
  - Less speed deviation (z=-2.395, p=0.017)
  - Time spent looking away from road significantly increased (z=-2.803, p=0.005)
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## **Results**

### **“Redundant HUD” compared to “Spread out” for “driving only”**

- Less lane position deviation ( $U=13.000$ ,  $p=0.016$ )
  - Lower HDD duration ( $U=13.000$ ,  $p=0.016$ )
  - Higher HUD duration ( $U=18.000$ ,  $p=0.051$ )
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### **“Redundant HUD” compared to “Spread out” for “driving with task”**

- Less lane position deviation ( $U=16.000$ ,  $p=0.034$ )
  - Less time to notice message ( $U=3.000$ ,  $p=0.000$ )
  - Lower HDD duration ( $U=8.000$ ,  $p=0.003$ )
  - Higher HUD duration ( $U=0.000$ ,  $p=0.000$ )
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- 113 lane exceedences for “Redundant HUD”. 176 for “Spread out”
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- Data analyzed for every separate task from the time the message displaying the task appeared until 15s after the task was properly accomplished.
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## **Results**

### Mean detection times for each message (seconds)

Message number	1	2	3	4	5	6	7	8	9	10
Time to notice "Redundant HUD"	1.24	0.50	0.91	0.74	2.01	4.18	2.64	1.85	3.00	0.66
"Spread out"	9.25	12.13	5.56	11.04	8.52	4.33	8.99	1.52	3.80	9.07
	IF	CS	HDD	IF	HUD	HDD	IF	HUD	HDD	CS

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## Results

Mean detection times for each warning (in seconds)										
Warning number	1	2	3	4	5	6	7	8	9	10
Placement spread	IF	CS	HDD	IF	HUD	HDD	IF	HUD	HDD	CS
Time to notice redund.	1.17	2.24	2.22	1.00	1.32	3.04	1.56	4.89	5.43	0.95
Time to notice spread.	4.28	13.20	1.98	0.90	4.20	3.13	2.54	3.27	3.34	18.16

## Results - Comparison with other study



- Messages in “Redundant HUD” are:
  - Noticed faster
  - Looked upon more frequent
  - HUD is preferred over HDD
  - Less lane deviation
- No physiological differences

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## Results



Thank you!

## Dependent measures and their definitions

	Measure	Definition
Driving performance	Mean speed	Vehicle's mean speed
	Standard deviation of speed	How much the vehicle's speed deviates
	Maximum speed	Maximum speed reached
	Standard deviation from speed limit	How much the vehicle's speed deviates from the posted speed limit
	Standard deviation of lane position	How much the driver's lateral control of the vehicle deviates
	Number of lane exceedences	The number of times more than half of the vehicle is exceeds the lane
Physiological measures	Mean <u>GSR</u>	Difference in Galvanic Skin Resistance while relaxed and while driving
	Mean temp	Difference in mean hand temperature while relaxed and while driving
	Mean HR	Difference in drivers mean Heart Rate while relaxed and while driving
Glance measures	Time to notice	Time from a message appears until gaze is directed towards display
	Glance frequency	Number of glances to the message while it is displayed
	Total glance duration	Total time the message display is gazed upon
	Mean glance duration	Mean time the message display is gazed upon
	Gaze duration off road scene ahead	Time the gaze is not directed towards the road scene ahead
	HUD duration	Total time spent viewing the Head-up display
	HDD duration	Total time spent viewing the Head-down display
	Task completion time	The time from a message appears until the task is completed

# Additional material

# Körsimulatorexperiment - driving performance

Dependent measures:

Mean speed

Standard deviation of speed

Maximum speed

Standard deviation from speed limit

Standard deviation of lane position

Number of lane major lane exceedences



A simulator is predictable and have excellent prerequisites for experimental testing

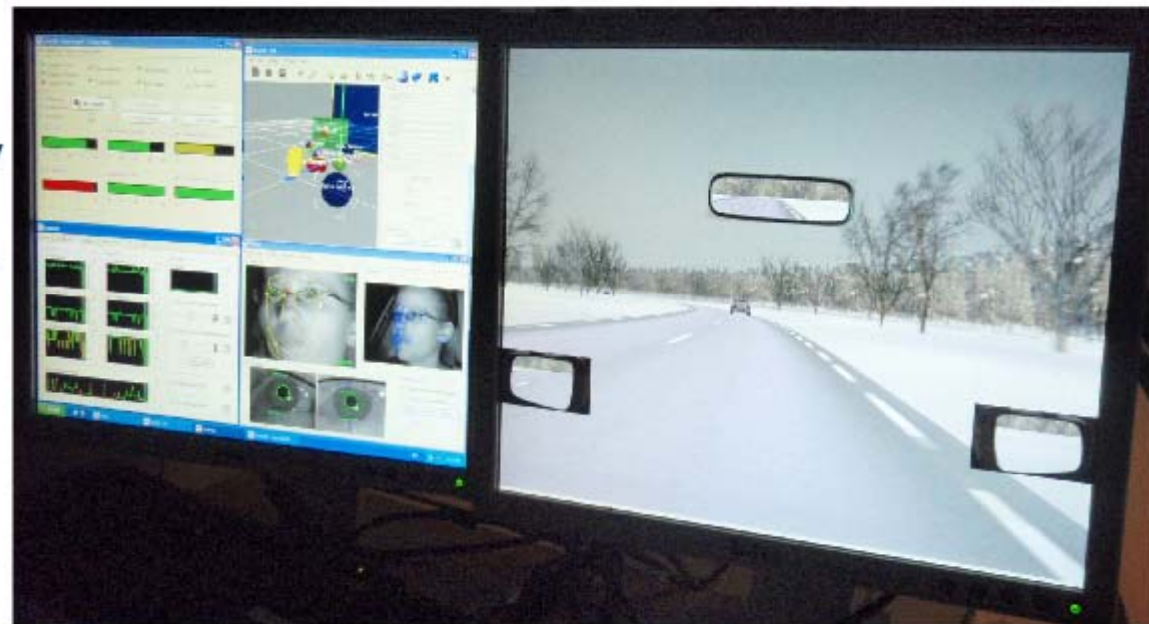
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## Additional material

# Körsimulatörexperiment - eye tracking

Dependent measures:

- Time to notice warning
- Glance frequency to warning display
- Total glance duration warning disp.
- Mean glance duration warning disp.
- Total time eyes off road
- HUD glance duration
- HDD glance duration
- IF glance duration
- CS glance duration



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## Additional material

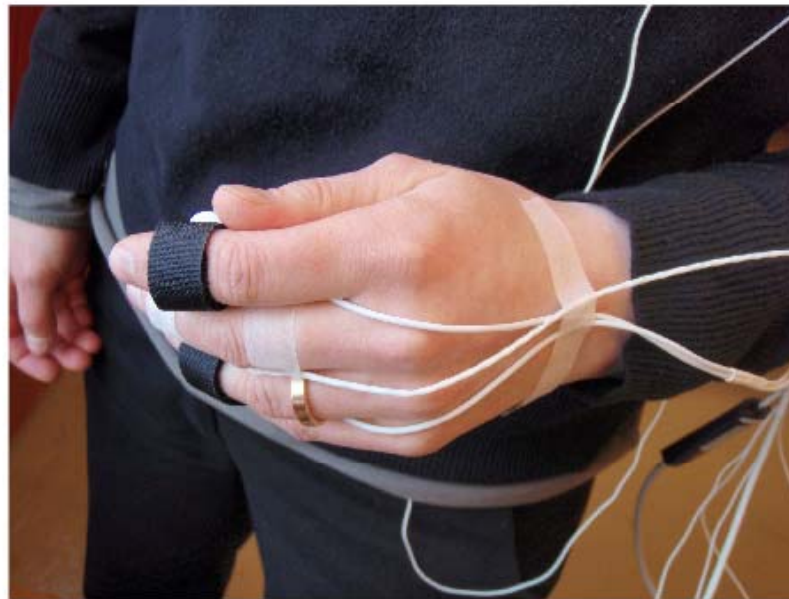
# Körsimulatörexperiment - physiological measures

Dependent measures:

Mean Galvanic Skin Resistance (good measure on stress)

Mean hand temperature

Mean Heart Rate



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## Additional material