

***Characteristics of Voice-Based
Interfaces for In-Vehicle Systems
and Their Effects on Driving
Performance***

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Background

■ **Categories of Distraction**

- Peripheral distraction
 - Visual interference
 - Manual interference
- Attentional distraction
 - Cognitive interference

Background

- **Manufacturers use voice interfaces to reduce distraction. Characteristics include:**
 - Text-to-speech and voice recognition capabilities
 - Hierarchical menu structures
- **Our previous research indicates that voice interfaces:**
 - Reduce peripheral (visual and manual) distraction
 - Have little effect on cognitive (attentional) distraction

Program Objectives

- **Develop protocol and metrics for assessing distraction potential of tasks performed using voice interfaces**
- **Use protocol to assess selected attributes of secondary tasks and voice interfaces**

Traveler Information Systems

- **Accessible via telephone by dialing '511'**
- **Implemented in parts of the United States since 2000, 511 service will be:**
 - Available in at least 25 states by 2005
 - Operational throughout the United States by 2010

Traveler Information Systems

- **Voice-activated navigation of hierarchical menu structures**
- **May be used by commuters and unfamiliar travelers**
- **Provide current information about:**
 - Traffic conditions - accident and construction delays
 - Road conditions – slippery, snow-covered etc.
 - Public transit

Research Objectives

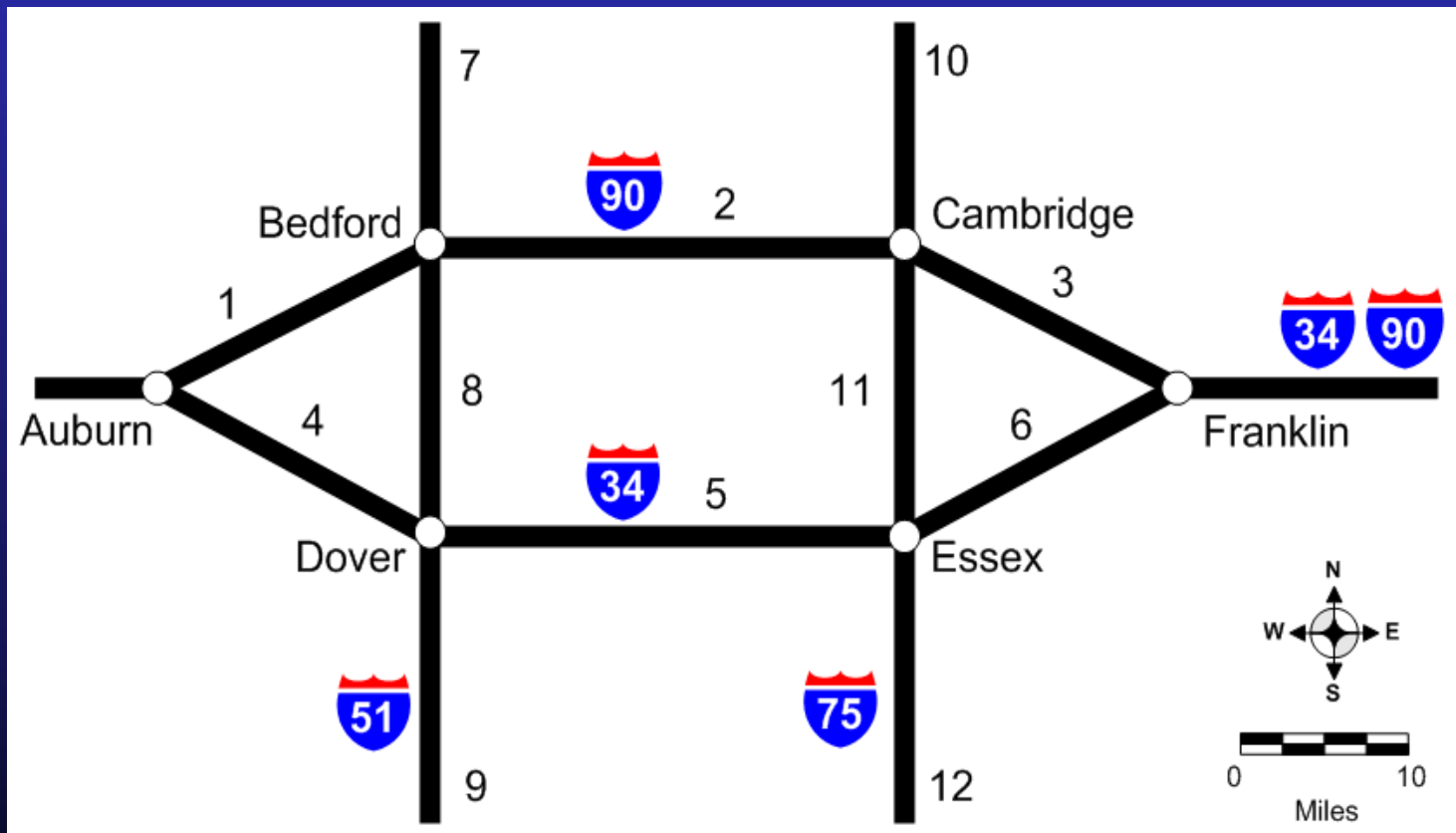
- **To determine whether selected secondary tasks degrade driving performance**
 - Simulated phone conversation
 - 511 information acquisition tasks
- **To evaluate the effects of specific task interface attributes:**
 - Required map use
 - Voice interface reliability

Research Approach

■ **We developed:**

- Simulated 511 system using a “Wizard of Oz” approach
 - Human replaces voice recognition component
- Navigation questions related to a hypothetical system of interstate roads

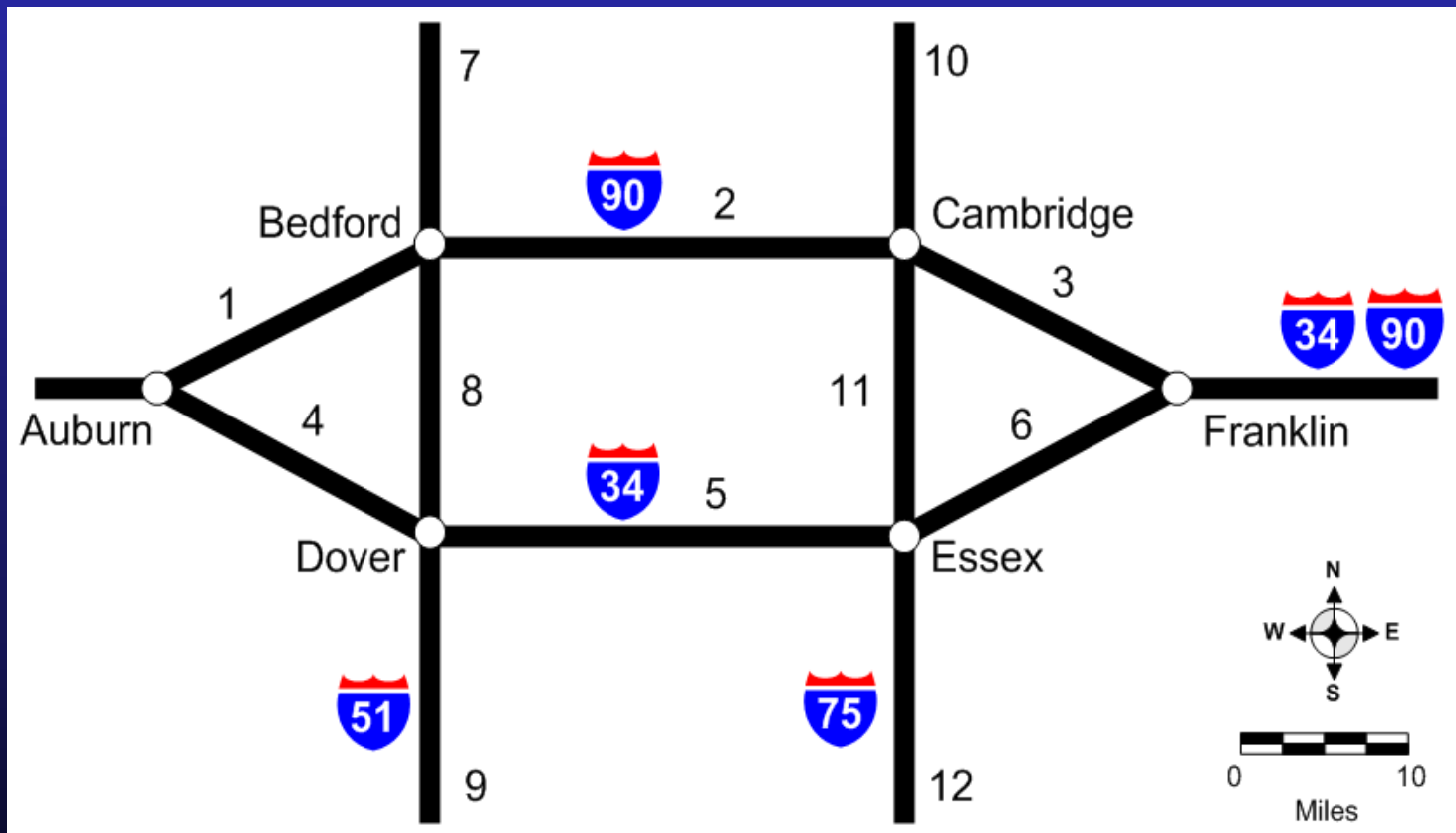
511 Task: Hypothetical Roadway System



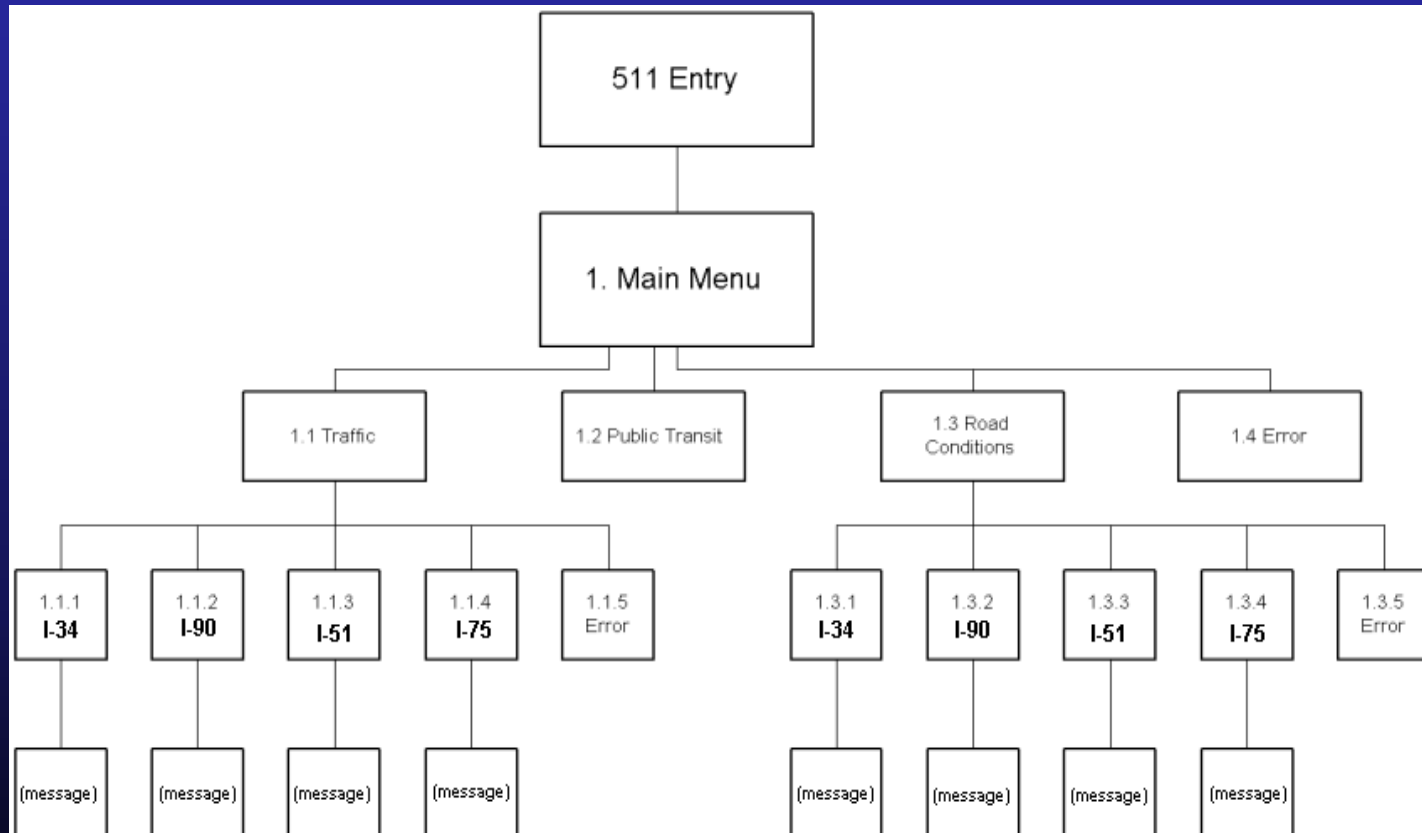
Example 511 Tasks

- Which route has better road conditions, I-34 or I-51? (No Map)
- Which segment has more incident-related time delay, segment 3 or segment 7 (Map required)

511 Task: Hypothetical Roadway System



511 Task: Hierarchal Menu Structure

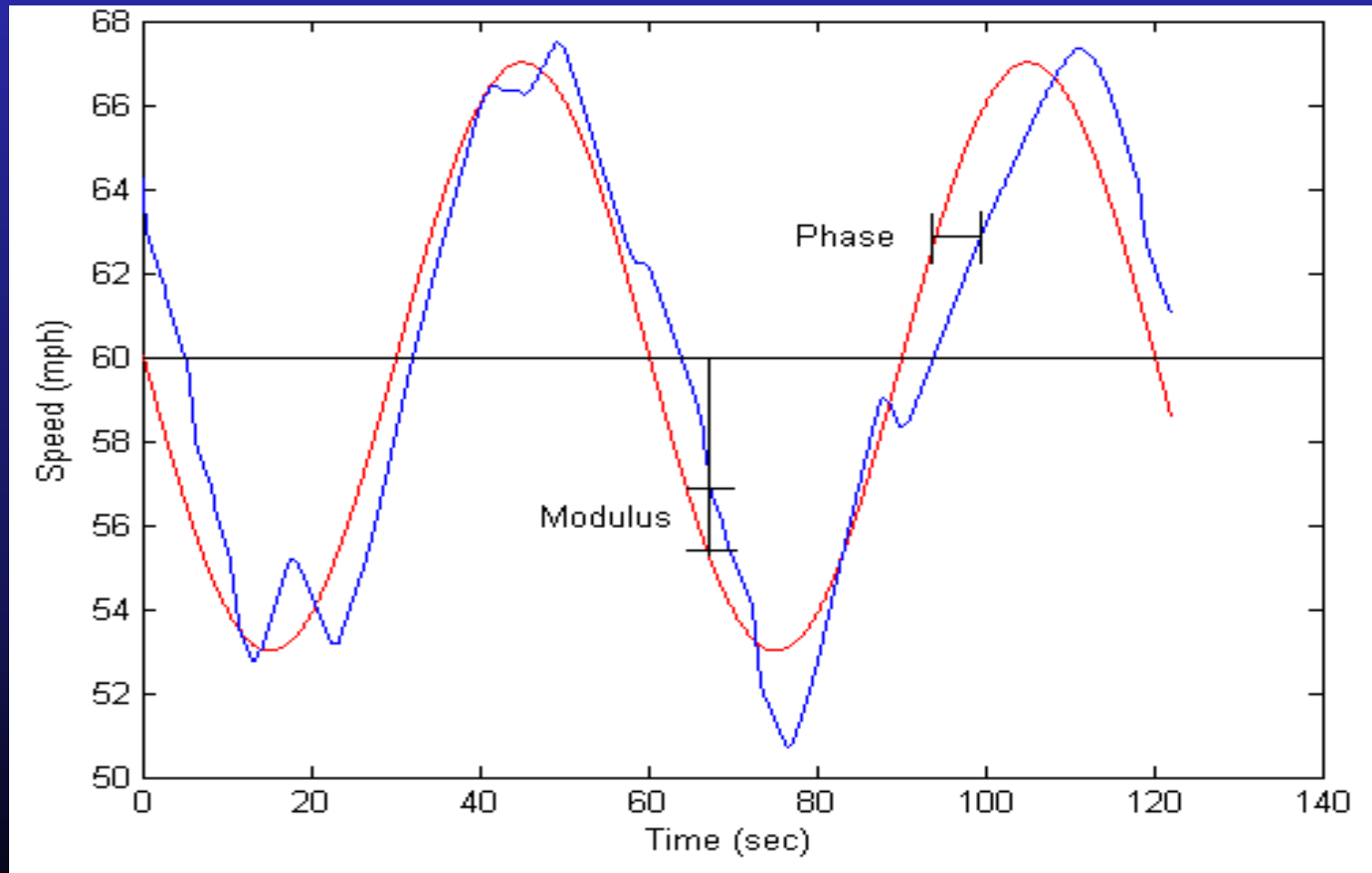


Research Approach

cont.

- **Primary (driving) task**
 - Car following
 - Peripheral detection task (PDT)
- **Secondary tasks (hands-free phone and voice interface)**
 - Simulated phone conversation task
 - Simulated navigation task (4 conditions)
 - Information acquisition mode (auditory vs. auditory + visual map)
 - System reliability (no voice recognition errors vs. 20% errors)

Car-Following Task



Peripheral Detection Task



Experimental Design

■ **Independent variables:**

- Driver age group
- Secondary task
- Lead vehicle speed signal




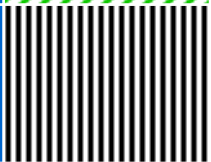
■ **Dependent measures:**

- Car following (coherence and delay)
- Vehicle control (steering entropy)
- Peripheral target detection (% correct, RT)
- Subjective workload rating

Method

- **Thirty-six drivers (18-25, 30-45, 50-60)**
- **Drivers drove a 1996 Honda Accord and followed a lead vehicle on TRC's 7.5-mile test track**
 - Data collected on both 2 mile straight segments
 - Speeds varied between 45 and 60 mph

Categories of Driving Performance Measures

Category	Interference	Primary Measures	Color Code
Vehicle Control	Peripheral	Steering entropy	
Car Following	Attentional	Coherence, Delay	
Target Detection	Peripheral	% Detected, Response Time	
Subjective Rating	Overall	RSME Workload	

Overview of Results

- **Baseline comparisons**
- **Interface design hypotheses**
 - Map vs. No Map
 - Error vs. No Error
- **Differences between Phone and 511 tasks**

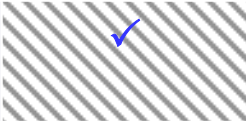

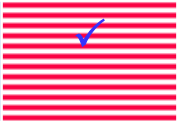
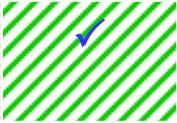
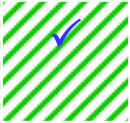
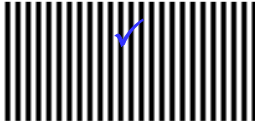






Baseline Comparisons

	Vehicle Control	Car Following		Target Detection		Subjective Rating	
Comparison	Steering Entropy	CF Coherence	CF Delay	PDT Detect	PDT RT	RSME Workload	Total
No Error	✓	✓	✓	✓	✓	✓	6
Error	✓	✓	✓	✓	✓	✓	6
Map	✓	✓	✓	✓	✓	✓	6
No Map	✓	✓	✓	✓	✓	✓	6
Phone	✓			✓	✓	✓	4

Summary of Results: Baseline Comparisons

- **All Secondary tasks degraded driving performance.**
 - 511 tasks degraded all categories of driving performance.
- **Phone conversation task was least disruptive**
 - Phone conversation did not affect car following performance.

Interface Design Comparisons

	Vehicle Control	Car Following		Target Detection		Subjective Rating	
Comparison	Steering Entropy	CF Coherence	CF Delay	PDT Detect	PDT RT	RSME Workload	Total
Map vs. No Map							5
Error vs. No Error							0

Summary of Results: Interface Design Issues

- **Tasks requiring map were more disruptive than similar tasks not requiring map.**
 - Impairment observed on 5 of 6 key performance measures
- **Increased voice recognition errors did not affect driving performance.**
 - No differences observed

Phone vs. 511 Task

	Vehicle Control	Car Following		Target Detection		Subjective Rating	
Phone vs.	Steering Entropy	CF Coherence	CF Delay	PDT Detect	PDT RT	RSME Workload	Total
Map	✓	✓	✓				3
Error		✓	✓				2
No Map		✓			✓		2
No Error		✓					1

Summary of Results: Phone vs. 511 Tasks

- **All categories of 511 tasks revealed greater degradation than phone conversation task on at least one measure**
 - Map Tasks were most different from phone task
- **Differences most apparent for car-following measures**
 - Suggests 511 tasks were more cognitively demanding
- **No differences in workload ratings**

Other Results

- **Effects of secondary tasks were consistent across all three age groups.**

Conclusions

- Test track protocol is sensitive to distraction effects of secondary tasks performed with voice interface and hands-free phone
- 511 tasks interfered with all aspects of driving performance
- Phone conversation task impaired target detection and vehicle control but not car-following performance

Safety Implications

- **Complex secondary tasks, including those requiring active navigation of hierarchical menu structures, are likely to disrupt driving more than simple phone conversations.**

Design Implications

- **Avoid unnecessary or redundant visual displays**
- **Drivers can tolerate systems with some voice recognition errors**
- **Minimize complexity of hierarchical menu structures**

Thanks for your attention!