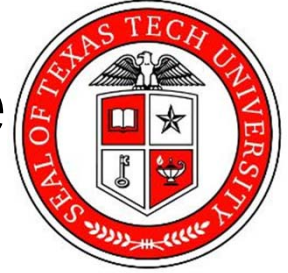


# Examining whether mental resource or response competition causes spatial cell phone conversations to impair driving



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Driver Distraction and Inattention  
Conference  
Sept. 5, 2011



# Background

- Cell phone conversations clearly impair driving performance
- Impairments are demonstrated by
  - Accident statistics
  - Epidemiological studies
  - Experimental studies

(Ascone, Lindsay & Varghese; 2009; Gugerty, Rakouskas, & Brooks, 2004; Kass, Cole, & Stanny, 2007; McKnight & McKnight; 1993; Redelmeier & Tibshirani, 1997; Strayer Drews & Johnson, 2003)

# Background

- Not simply due to drivers taking their eyes, hands, or both away from driving
  - Impairments occur even when drivers do not hold the phone
  - Impairments occur even when drivers are looking at the roadway

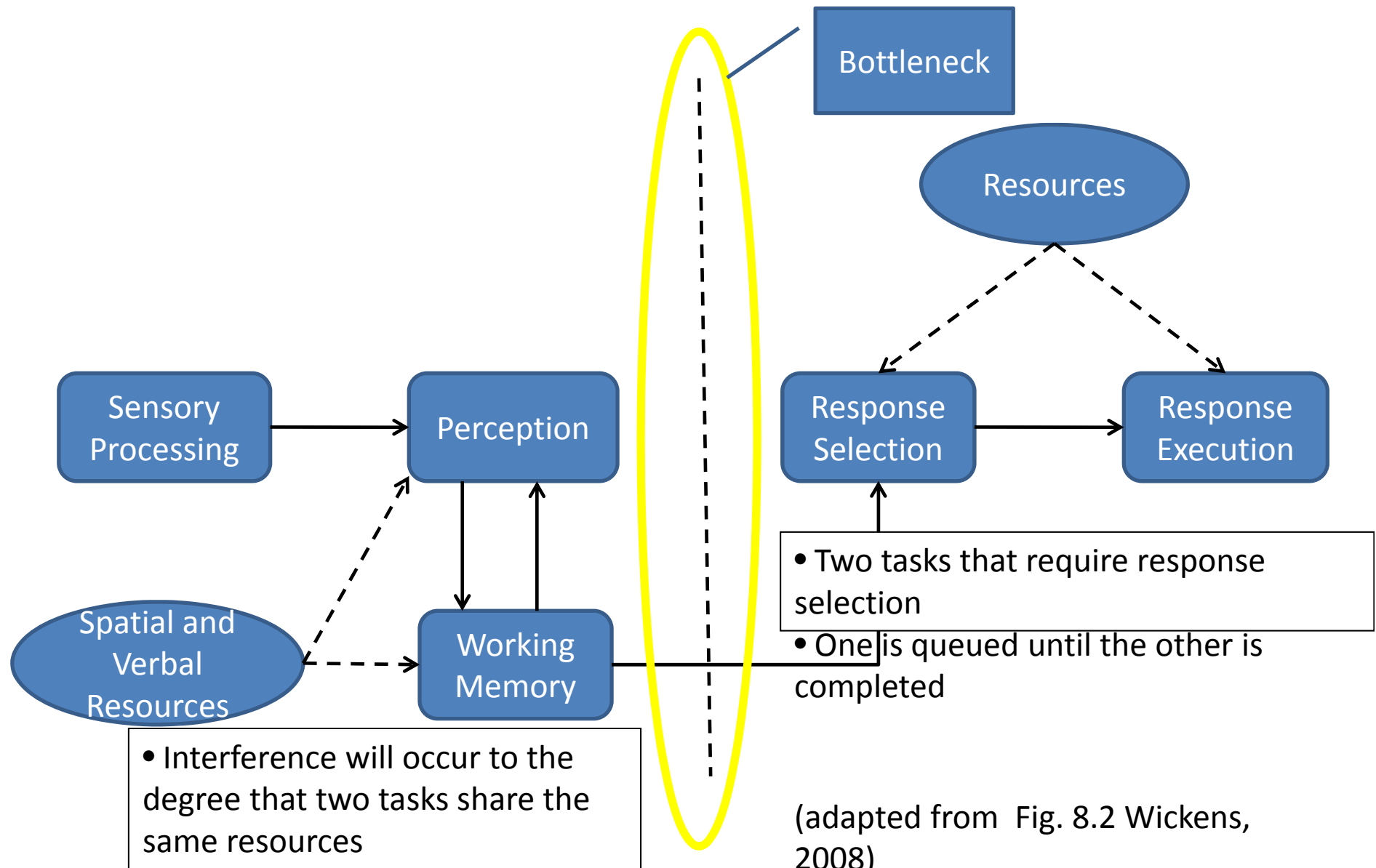
(Charlton, 2009; Hendrick & Switzer, 2007; Strayer & Drews, 2007)

# Background

- So, the explanation must be related to how drivers *process* information
- Driving while conversing is a dual-task activity
- Dual-tasking can be conceptualized through Wicken's Multiple Resource Theory

(Wickens, 1984, 2008)

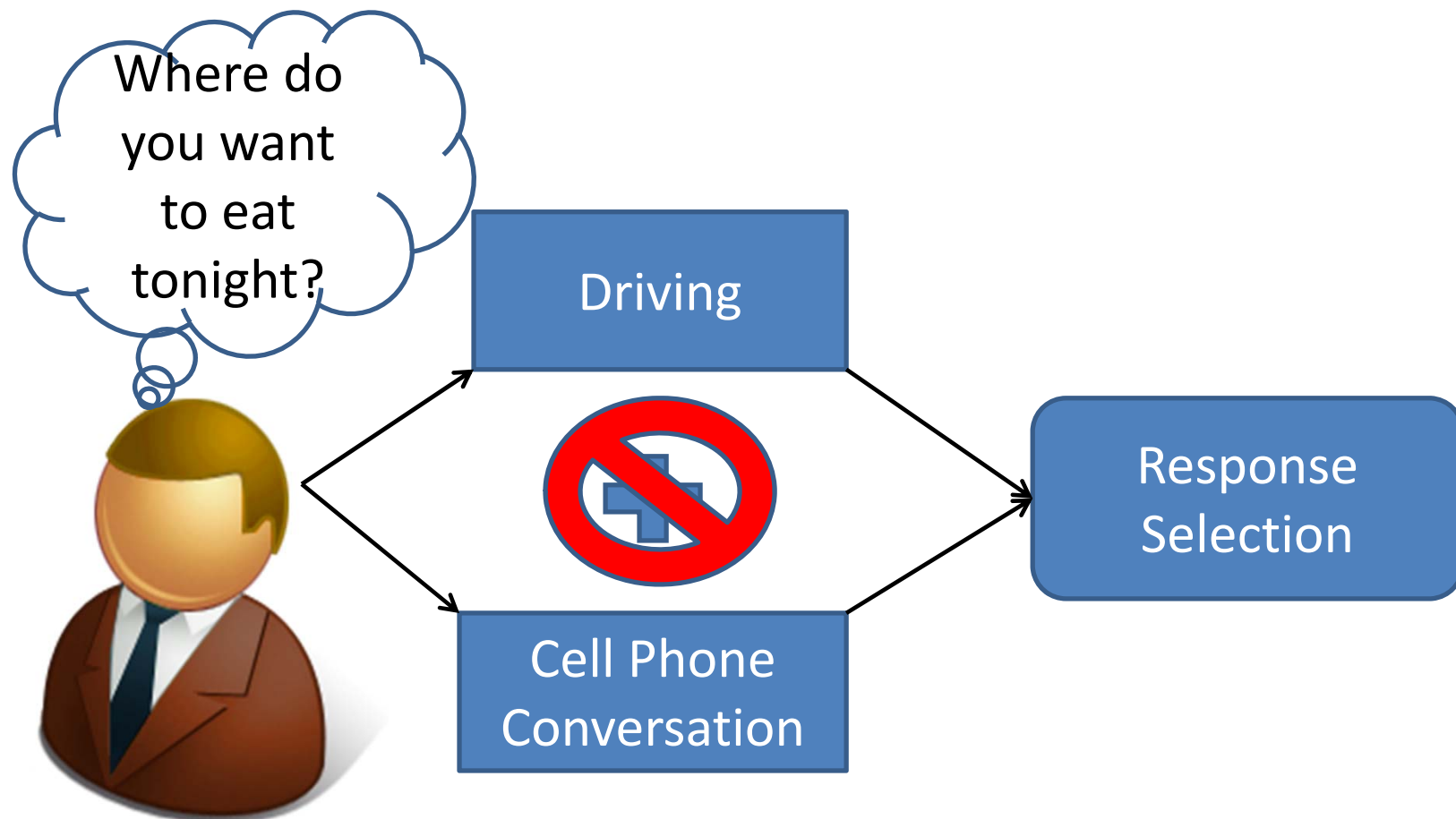
# Summary of Multiple Resource Theory



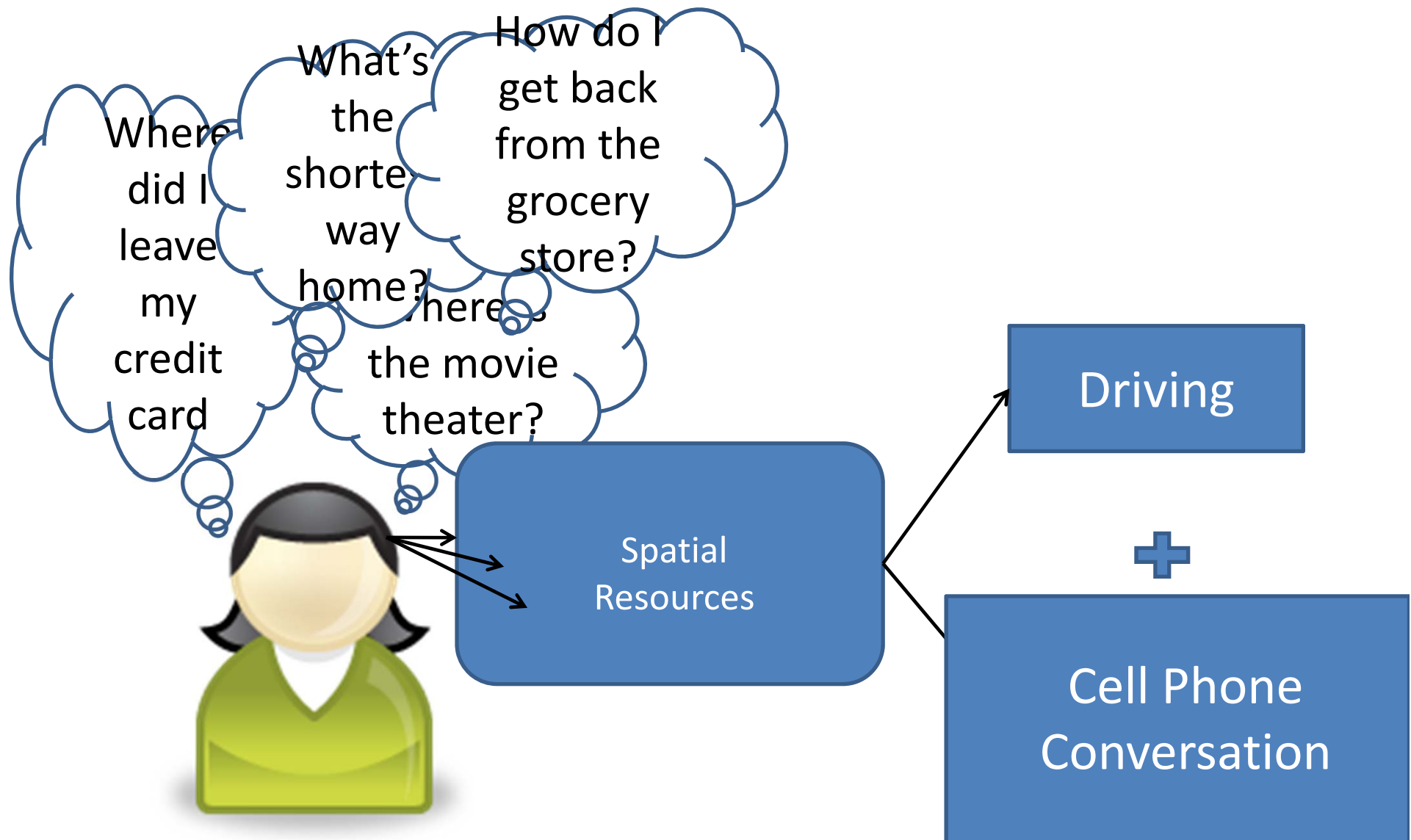
# The Cell Phone Driver

- Concurrent cell phone use while driving could impair performance because of
  - Response bottleneck
  - Spatial resource competition

# Response Bottleneck



# Spatial Resource Competition



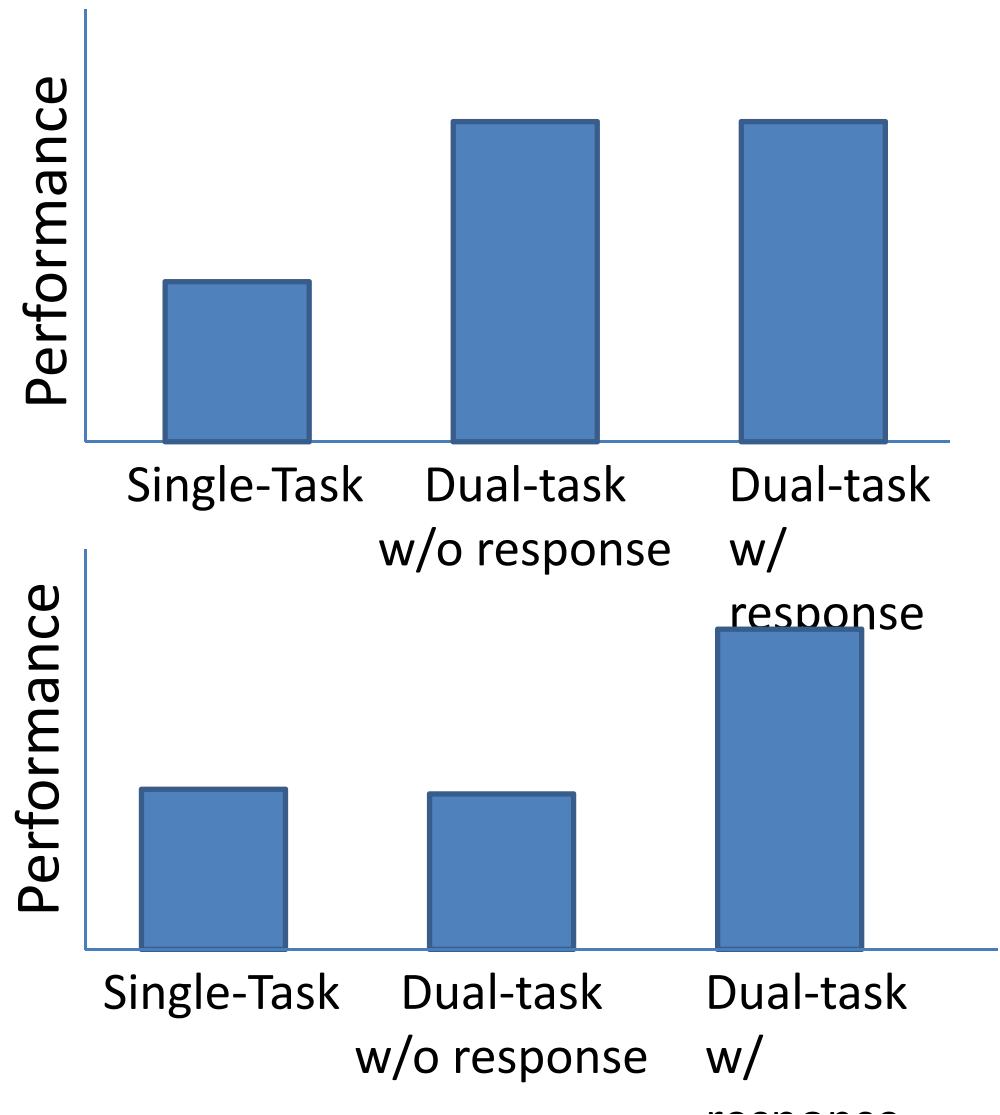


# Current Study

- Objective: To determine what mechanism is responsible for the impairments
  - Requires a specific type of concurrent task:
    - One that taps spatial resources
    - One that can have response selection or not
  - Need data from three different types of scenarios:
    - Single-task phase
    - Dual-task phase in which a concurrent task does not require response (e.g., shadowing tasks)
    - Dual-task phase in which concurrent task requires response (e.g., answering questions)
  - Analyze overall pattern of results across three phases

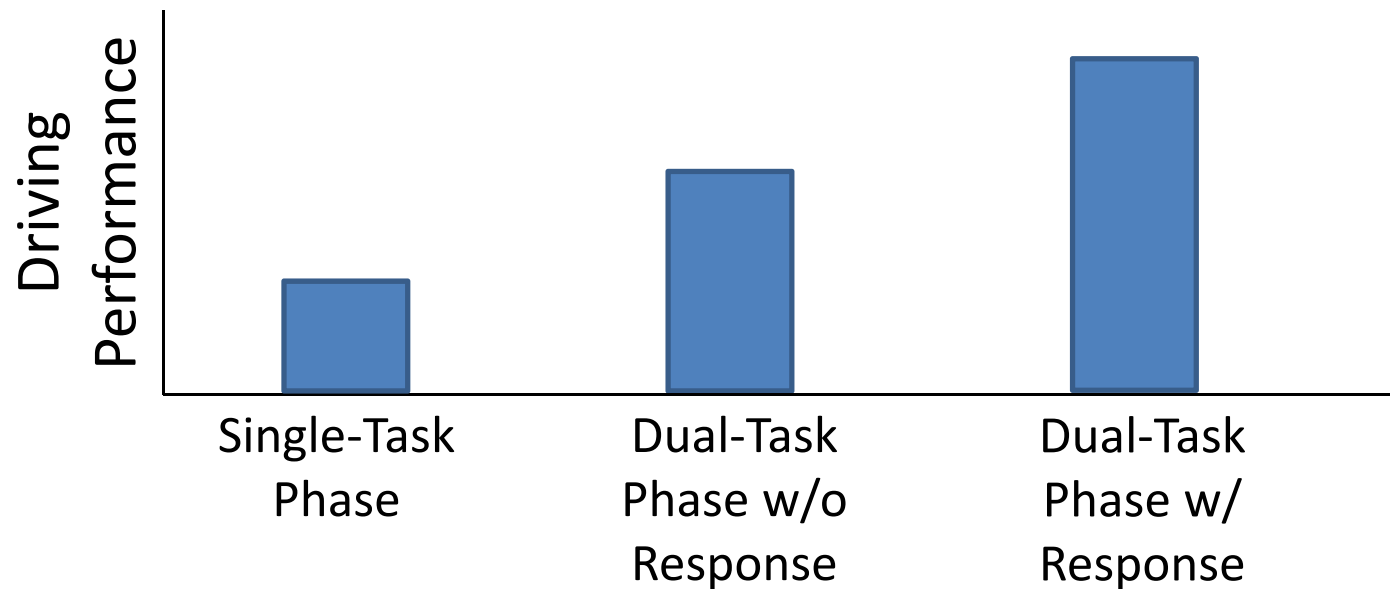
# Summary of Predictions

- Predictions that support shared resources
  - Dual-task without response < Single-task
  - Dual-task without response = Dual-task with response
- Predictions that support central bottleneck
  - Dual-task with response < Dual-task without response
  - Single-task = Dual-task without response

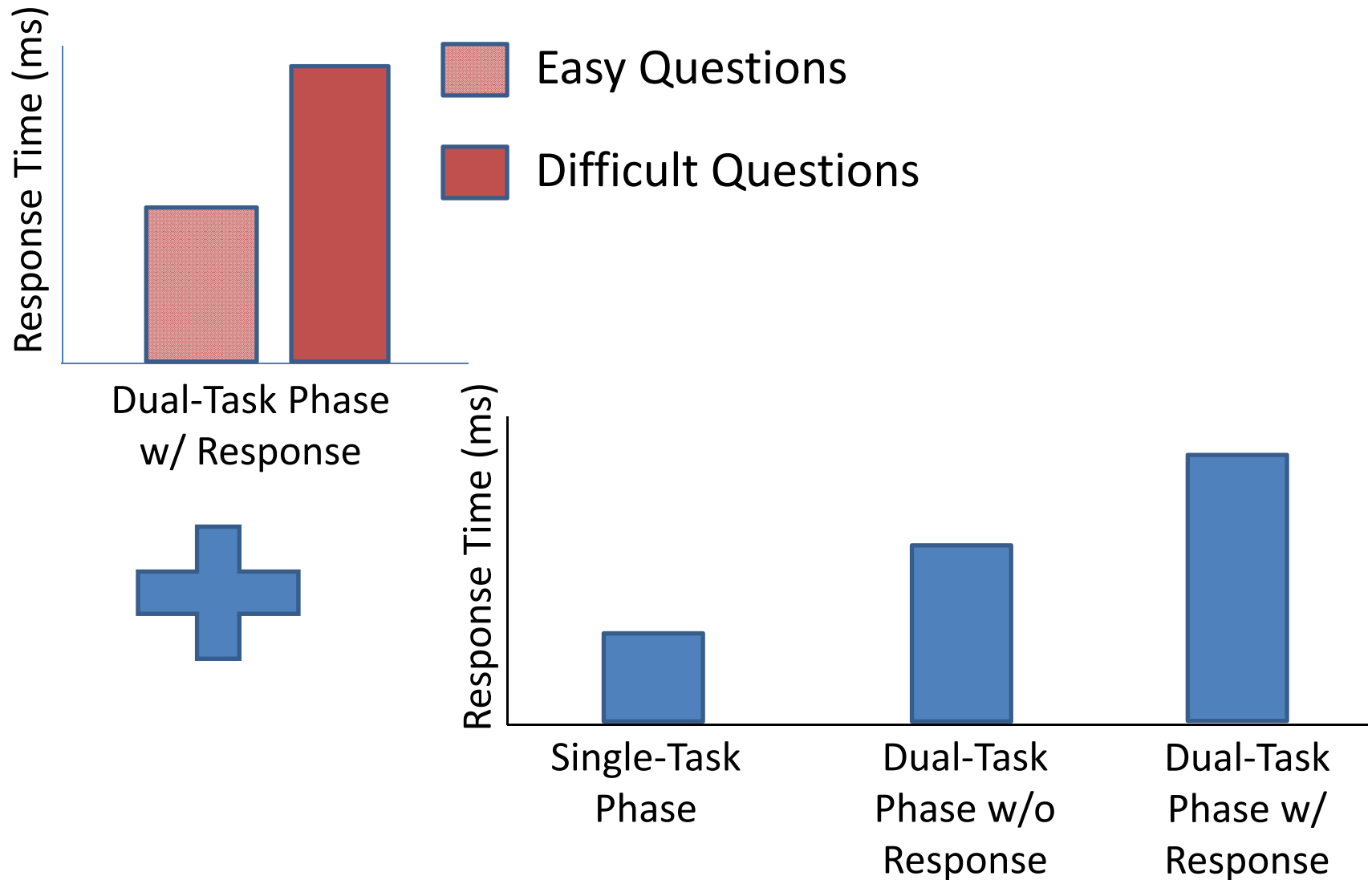


# Summary of Predictions

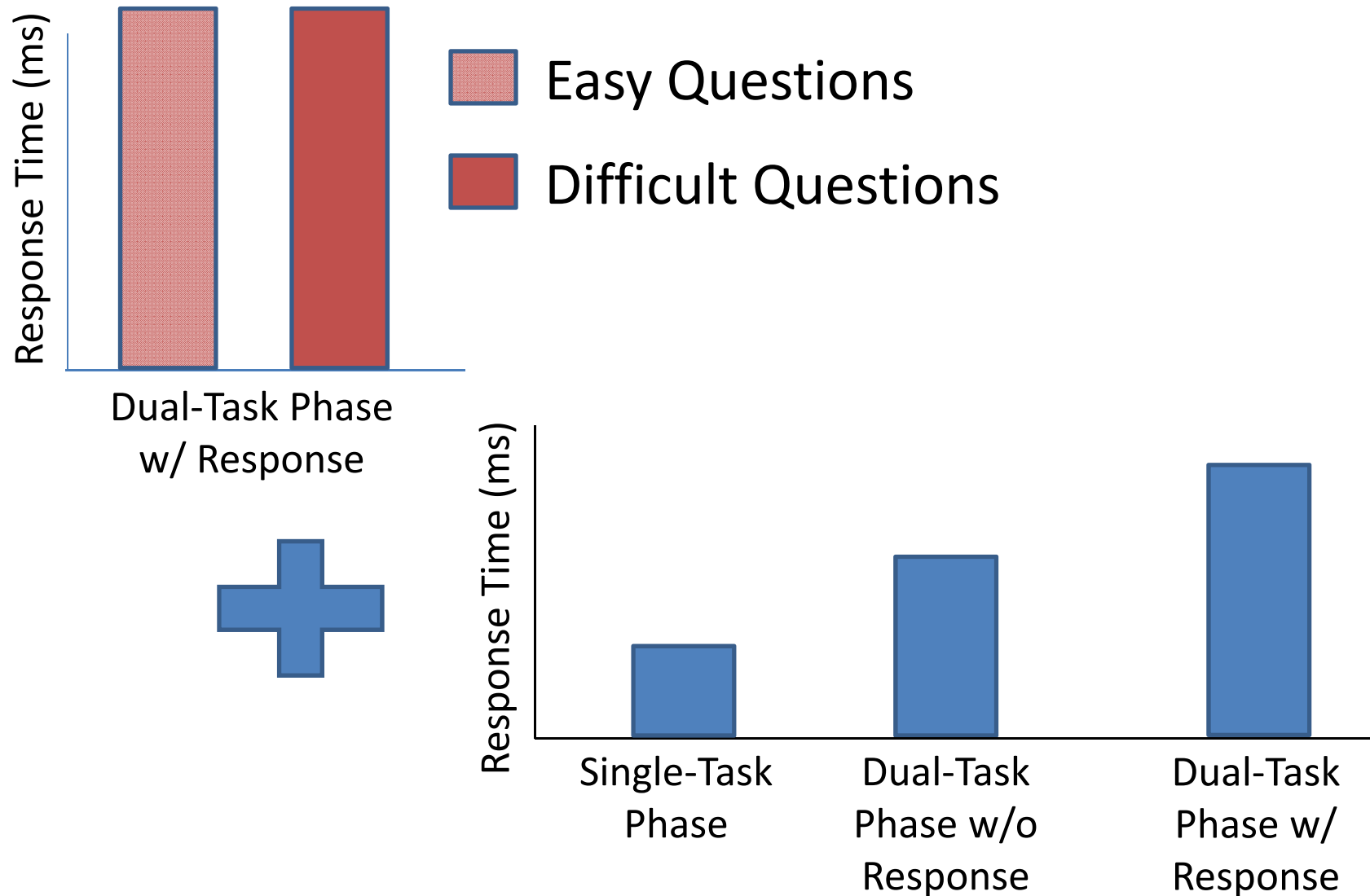
- Data that could support both predictions
  - Dual-task w/ response < Dual-task w/o response < Single-task



# Shared Resource Explanation



# Data that Could Support Both Explanations



# Objective

- To determine whether resource competition or response competition is responsible for impairments during driving and spatial cell phone conversations
  - Accomplished this by using a dual-task paradigm with a spatial route task

# Spatial Route Task

- Spatial route task developed to compare the two explanations:
  - Participants listened to a story about an imaginary city while
    - Shadowing its contents (which does not require response selection)
    - Responding to inquiries about the story (which does require response selection)

# Spatial Descriptions

- Four sentences with common referents that described objects at four different locations
- e.g., “Imagine that you are driving down a rural road towards a red barn. Before you reach the barn, you see a large wood fence on the left. After you pass the fence, you see a herd of cows on the right. After you pass the cows, you look in your rear view mirror and see a mountain range in the distance behind you.”





# Spatial Inquiries

- Easy: Require translational changes (e.g., Imagine that you mentally reversed your car. The wood fence is on the right.)
- Difficult: Require rotational changes (e.g., Imagine that you made a mental u-turn with your car, the herd of cows is on the left.)

# Participants

- 96 undergraduates from TTU
  - 48 males, 48 females
  - Current driver's license
  - Normal or corrected to normal vision
  - Screened for color deficiencies using Nomenclature test for colorblindness (Dvorine, 1953)

# Materials and Apparatus

- Demographic survey
- Hands-free device
- Spatial descriptions
- Spatial inquiries

# Materials and Apparatus

- Driving route
  - Urban traffic environment
  - Oncoming traffic and pedestrians
  - Intersections, but no turns
- Driving simulator
  - STISIM-Drive
  - Automatic transmission
  - Steering wheel, brake, accelerator
  - LCD monitor
  - Records number of collisions, reaction time, headway, average lane position

# Design

- Independent variables
  - Task load phases:
    - Single-task: Drive without performing concurrent task
    - Dual-task/Spatial description: Drive + shadow spatial descriptions
      - Does not require response selection
    - Dual-task/Spatial inquiry: Drive + respond to spatial inquiries about the shadowed content
      - Requires response selection and execution
  - Spatial inquiry type: Easy vs. Difficult

# Design

Dependent variables:

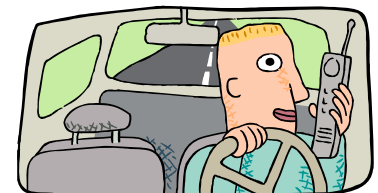
- Response times to braking instance of lead vehicle
  - Mean headway
  - Mean headway variability
  - Mean lane position variability
  - Mean speed
  - Mean collisions
- 
- Mean spatial inquiry accuracy
  - Response times to spatial inquiry statements

# Procedure

- Informed consent
- Demographic survey
- 5 min practice trial on simulator
- Instructed to give equal priority to cell phone and driving task
- Follow lead vehicle through simulated environment
- Respond to instances of lead-vehicle braking by pressing brake as quickly as possible

# Procedure

- Performed braking task during 3 repeating task phases in same order:
  - Single → Dual-spatial description → Dual-spatial inquiry
- Followed lead vehicle without concurrent task
- Heard route description and shadowed one sentence at a time
- Heard 3 spatial inquiry statements
- Responded by stating “true” or “false” aloud
- Completed a total of 24 spatial description blocks and 72 spatial inquiry responses
- Demographic Survey



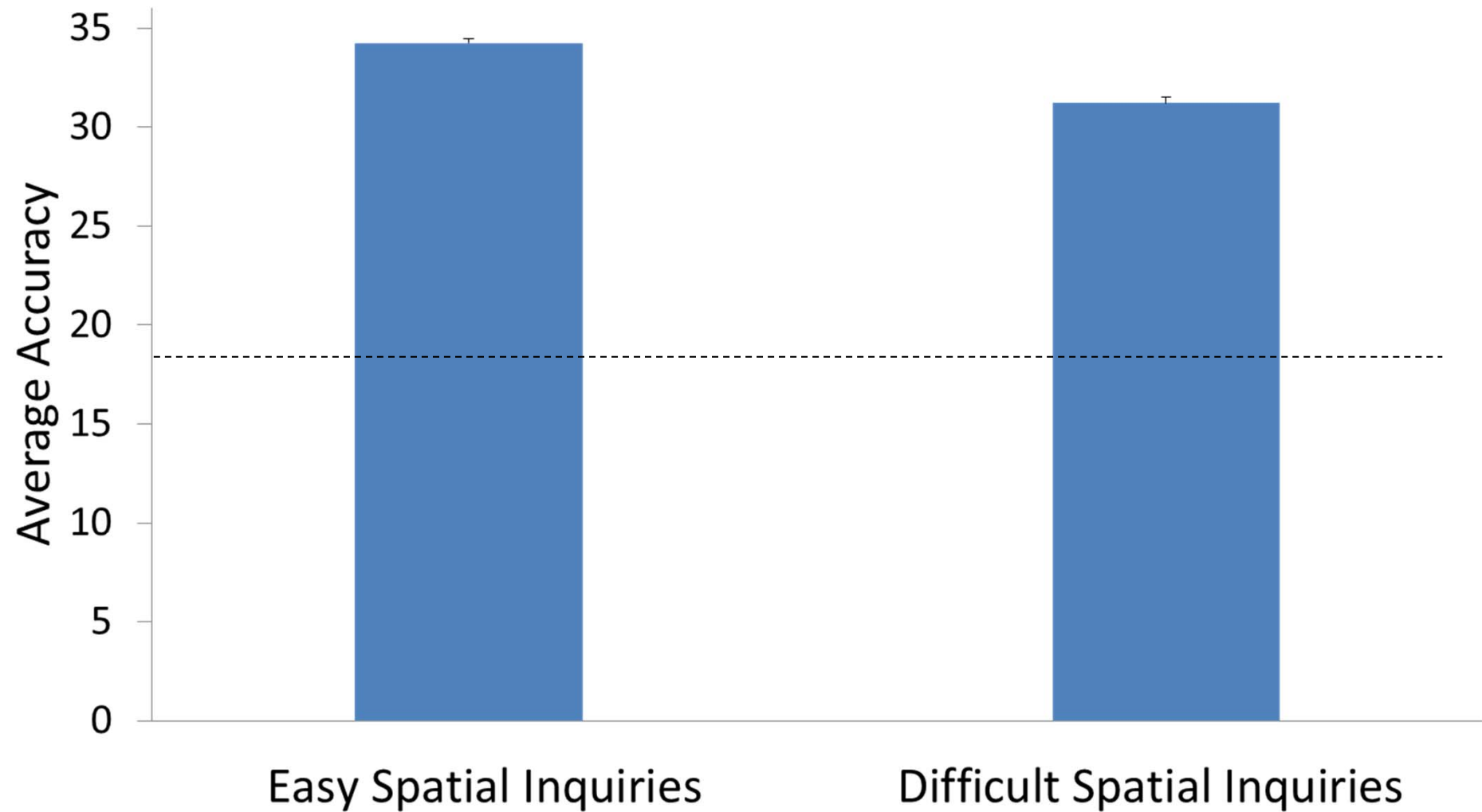


# Braking Task

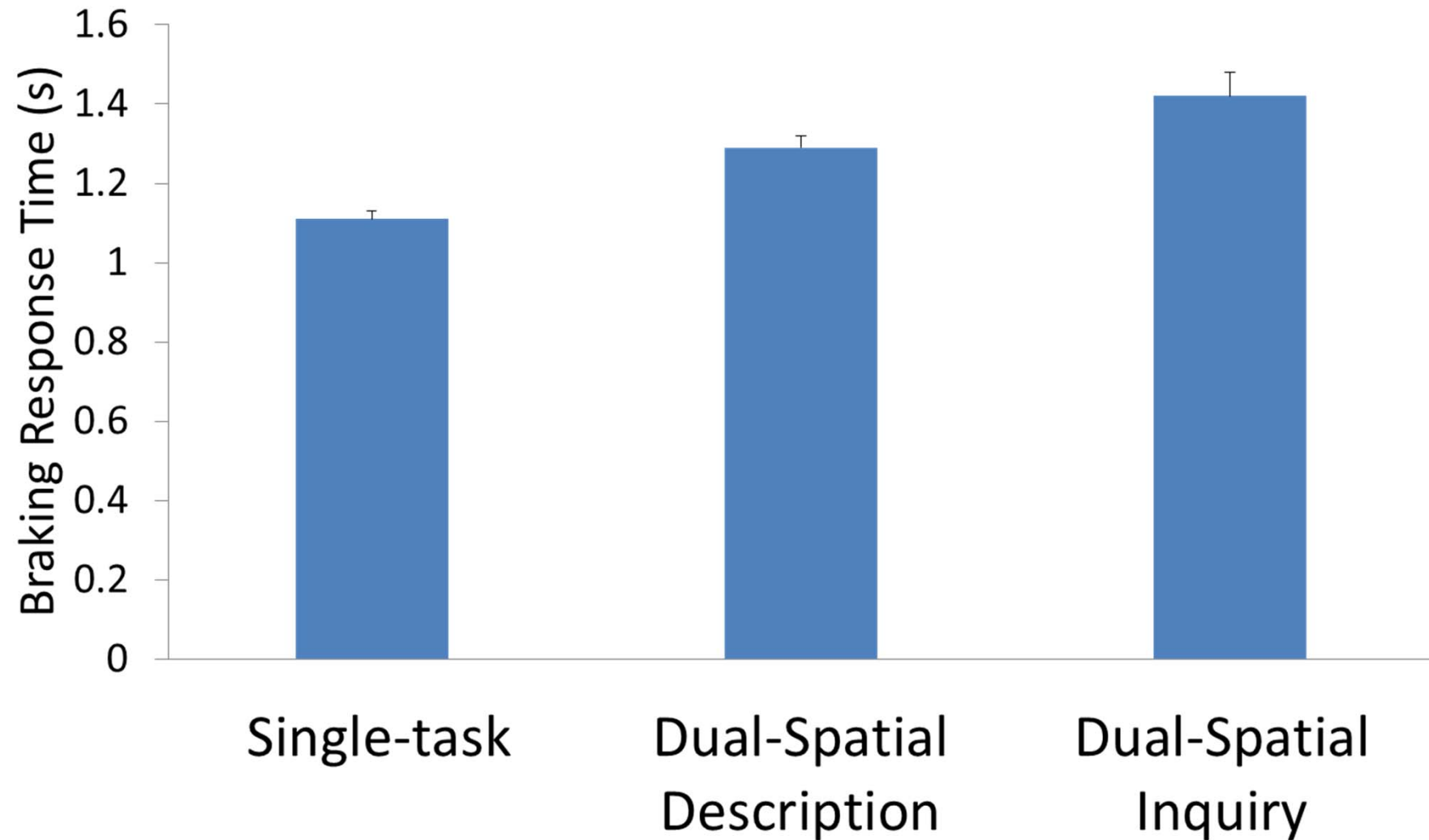
- Followed lead vehicle through simulated environment
  - Four-lane road without intersections or oncoming traffic
  - Trees and buildings randomly placed on sides of road
- Responded to instances of lead vehicle braking by pressing the brake as quickly as possible



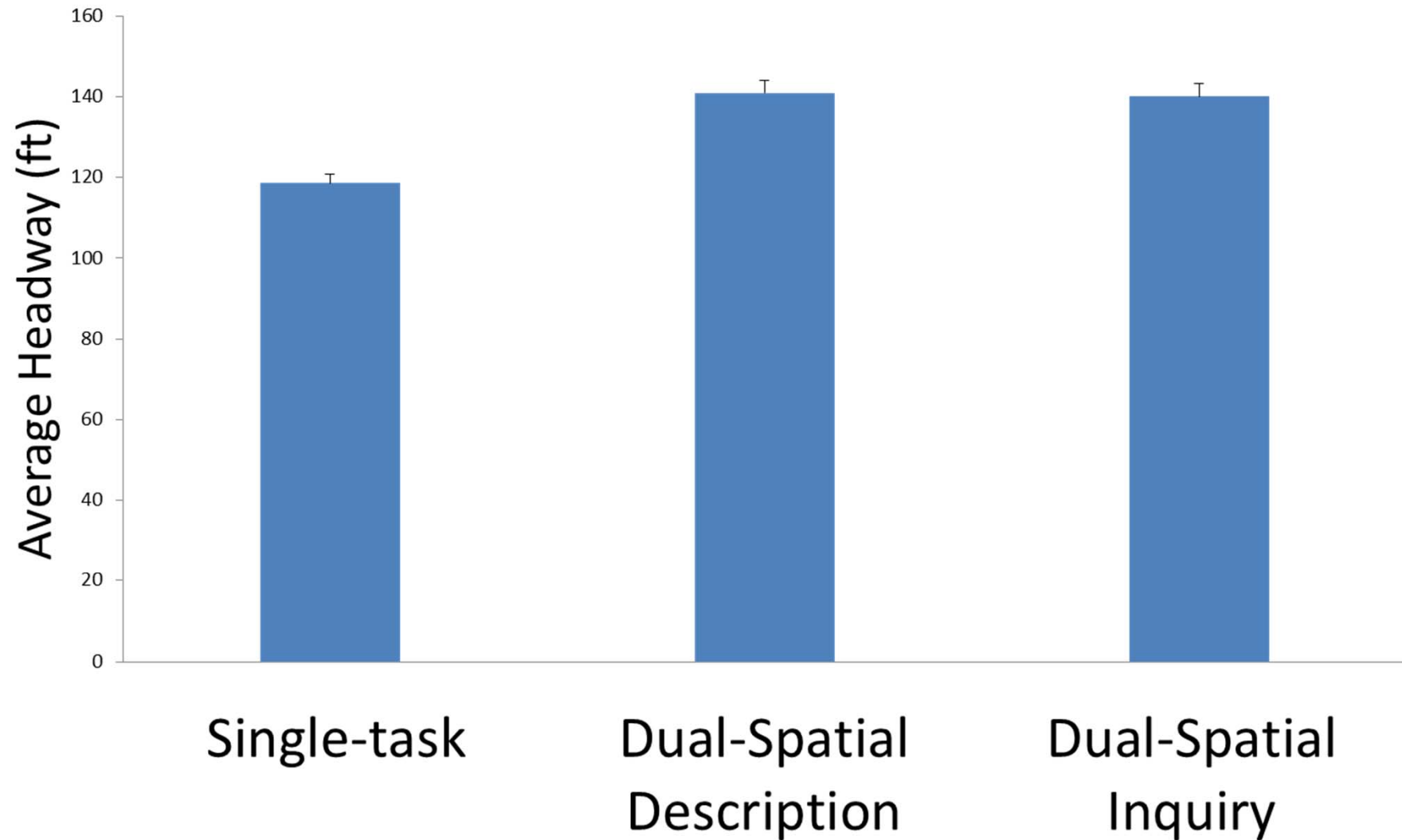
# Did participants perform as instructed?



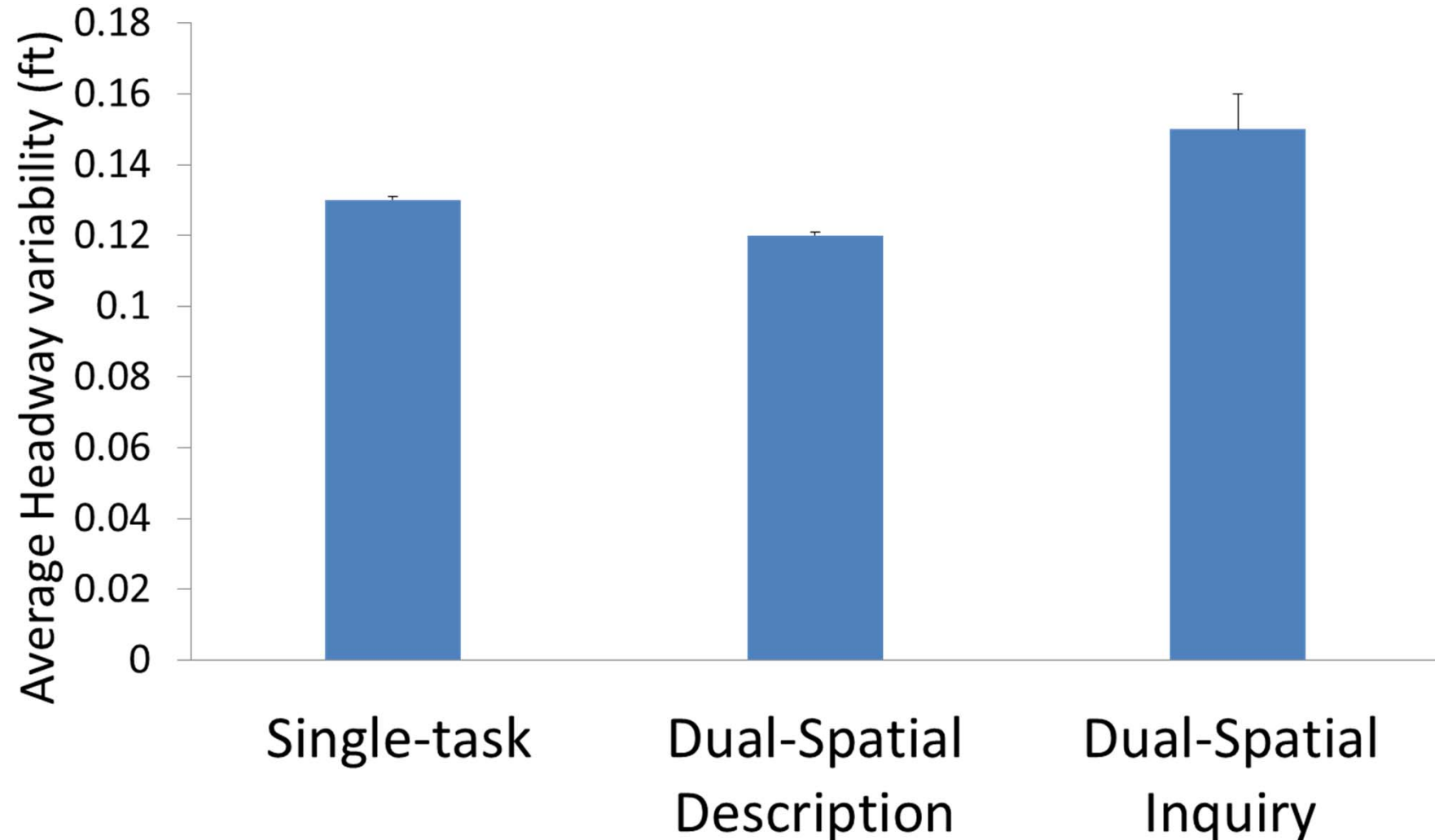
# Did shadowing & responding impair performance?



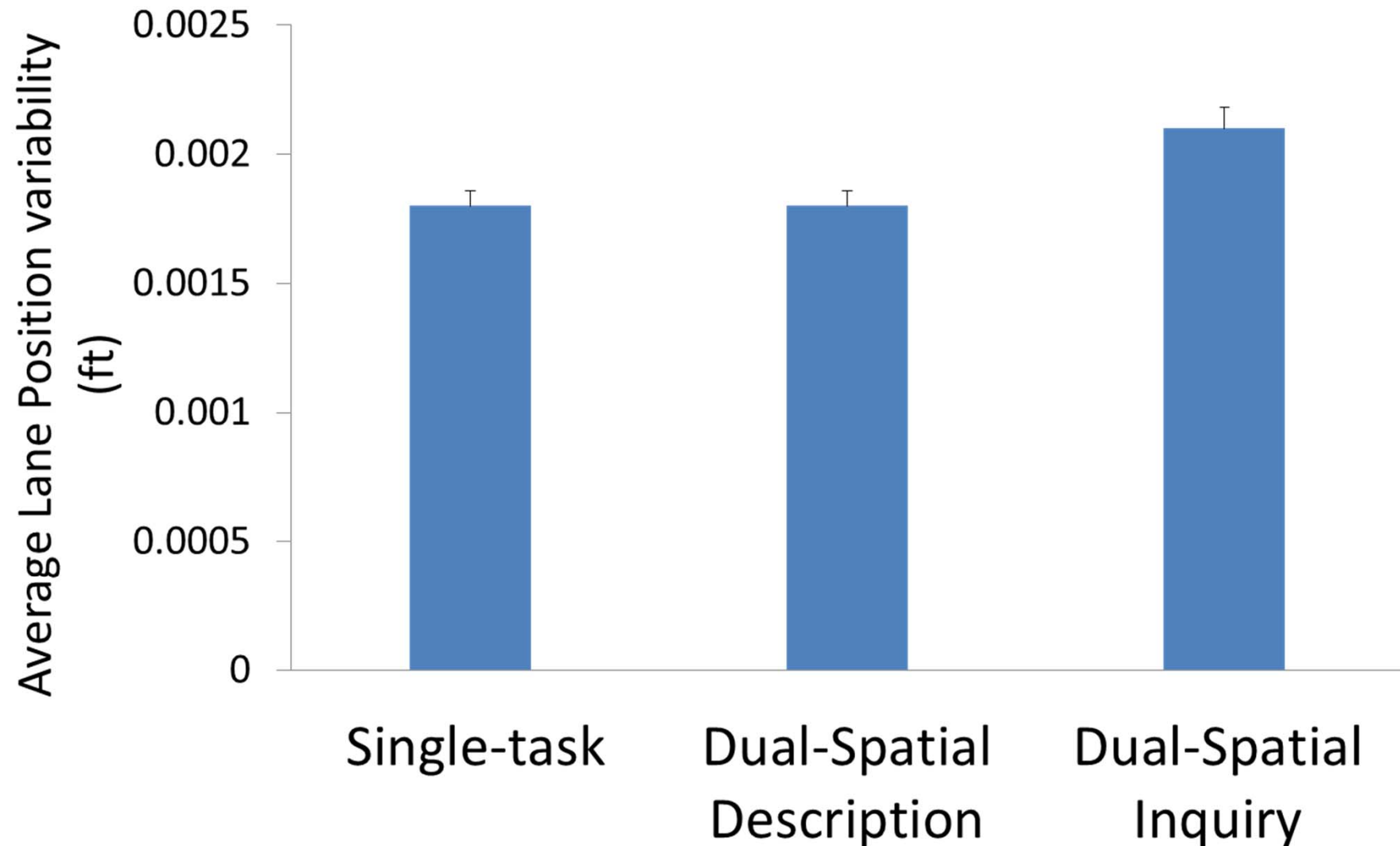
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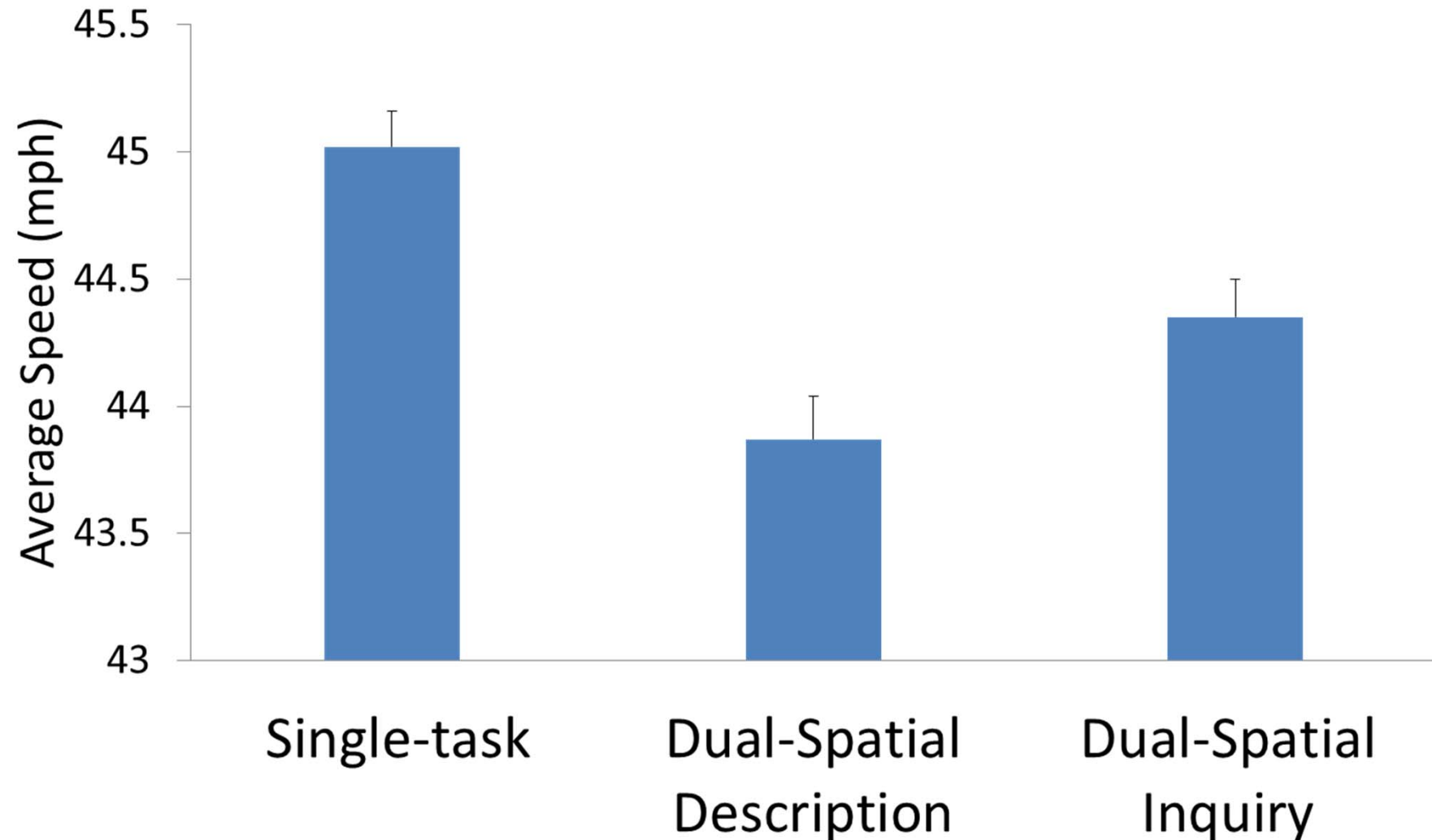
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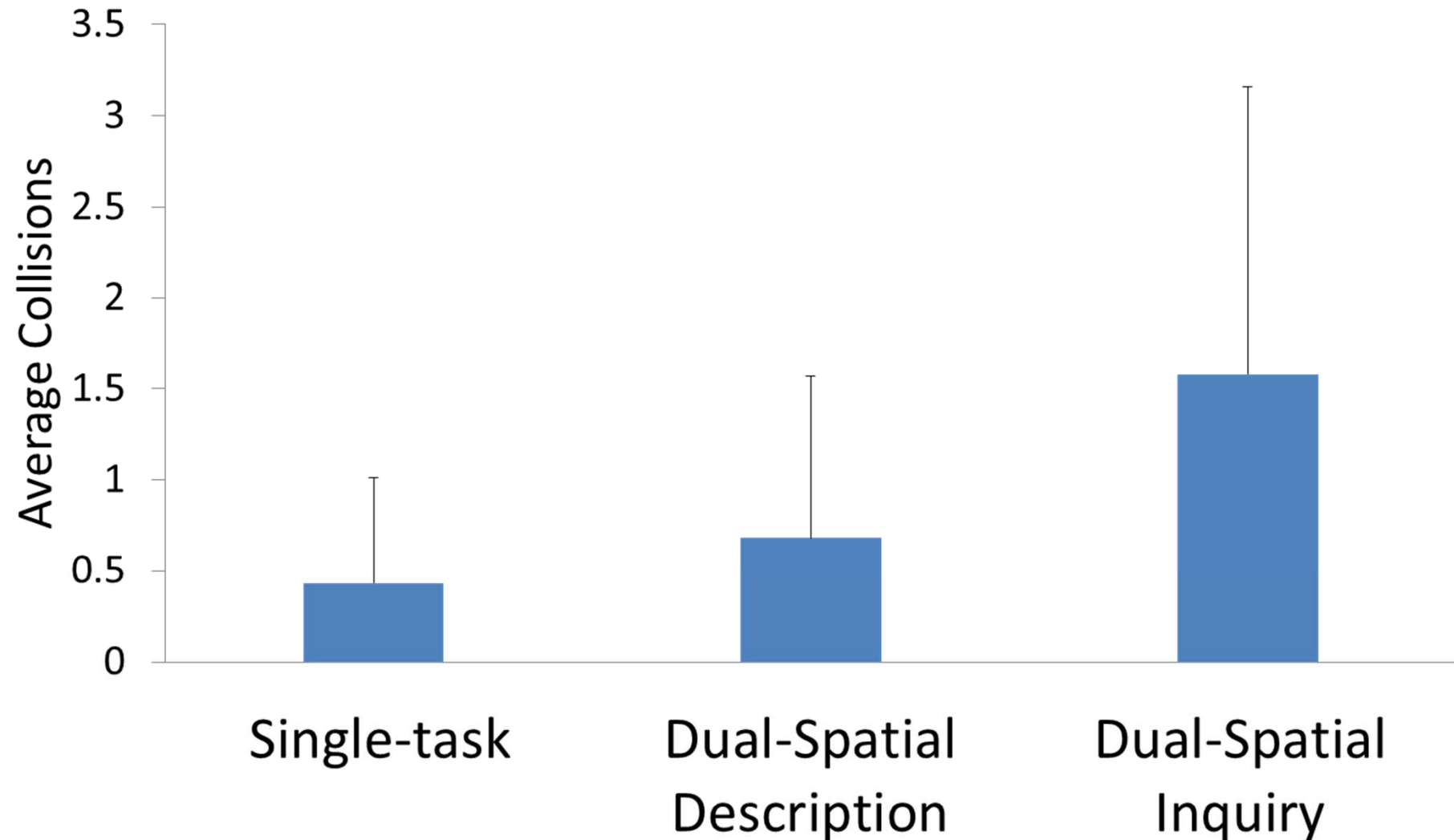
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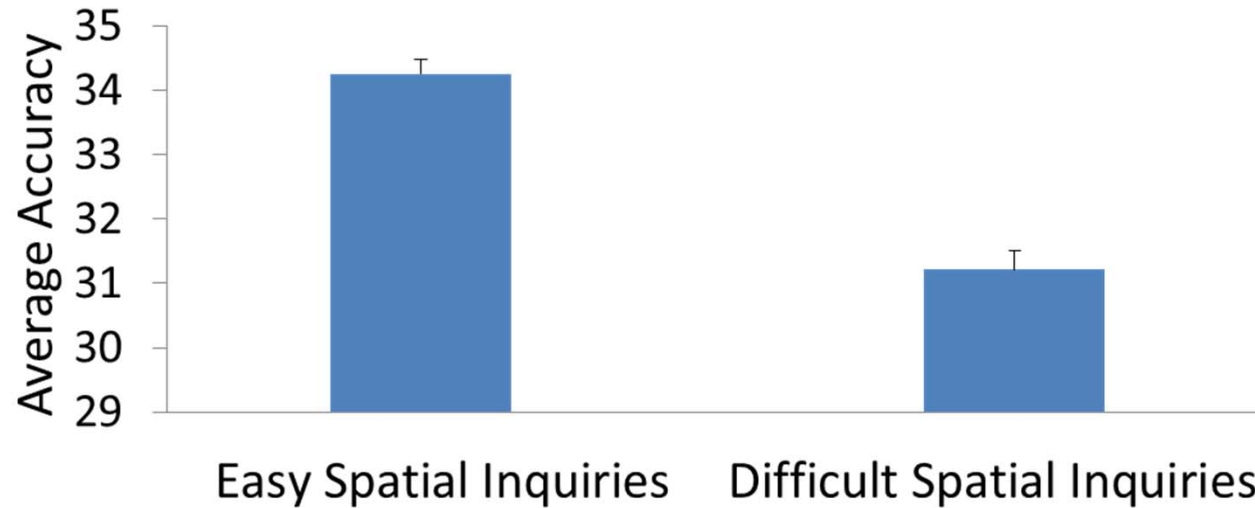


# Did shadowing & responding impair performance?

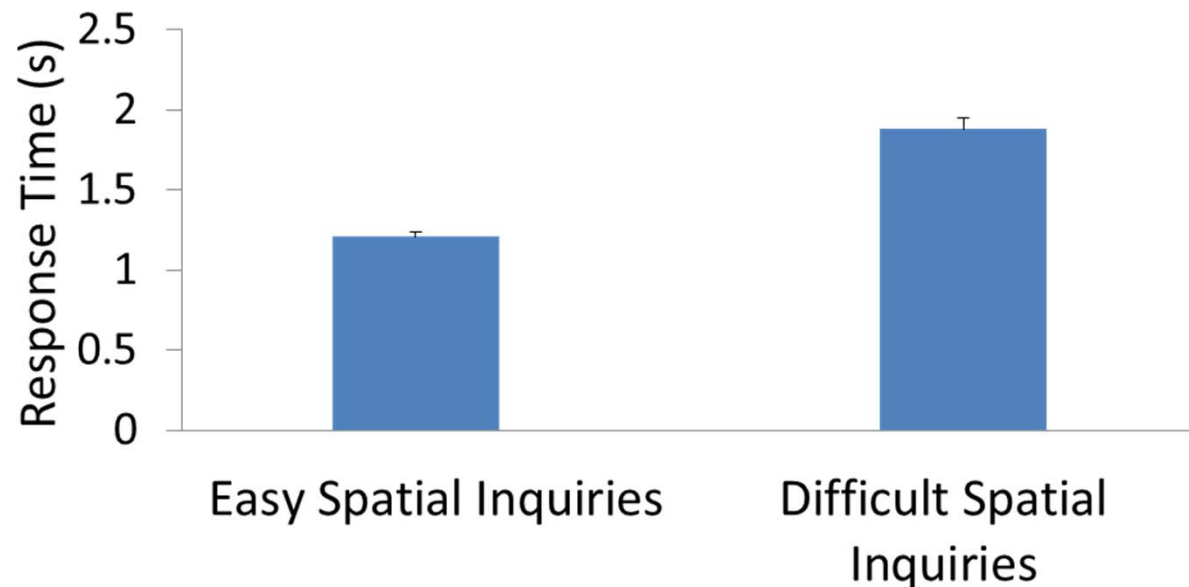




# Did inquiry difficulty affect performance?



Performance  
on Inquiries



# Did inquiry difficulty affect performance?

Performance Measure	Inquiry Difficulty	Mean	Standard Error	Result
Braking response time (s)	Easy	1.36	.04	$t(95) = -.02, p > .025$
	Difficult	1.36	.05	
Average headway (ft)	Easy	140.07	3.43	$t(95) = .06, p > .025$
	Difficult	139.82	3.51	
Average headway variability (ft)	Easy	.15	.01	$t(95) = -1.05, p > .025$
	Difficult	.16	.01	
Average lane position variability (ft)	Easy	<.01	<.01	$t(95) = 2.22, p < .025^*$
	Difficult	<.01	<.01	
Average speed (mph)	Easy	43.66	.24	$t(95) = -.66, p > .025$
	Difficult	43.87	.21	
Average collisions	Easy	.68	.08	$t(95) = 2.669, p < .025^*$
	Difficult	1.20	.08	

# Discussion

- Participants performed as instructed
  - Accuracy on spatial inquiries was significantly greater than chance
  - Participants weren't simply guessing
- Shadowing impaired performance:
  - Response times were slower, average headway was greater, average speed was slower, and there were more collisions compared to single-task performance
  - Driving performance was impaired by a task that did not require response selection
  - Competition for shared resources impacted driving performance

# Discussion

- Responding impaired performance:
  - Braking response times were slower, average headway varied more, average lane position varied more, average speed was higher, and there were more collisions compared with the shadowing condition
  - A task that required response selection impaired performance
  - Response competition impacted driving performance
- Inquiry Difficulty affected performance:
  - Participants responded faster and more accurately to easy spatial inquiries than to difficult ones
  - Participants' driving performance during easy and difficult inquiries differed for average lane position and collisions
    - Response competition explanation cannot account for these differences
    - Results support resource competition explanation

# General Discussion

- Theoretical applications:
  - Overall pattern indicated that both shadowing and responding impaired performance on 4 out of 6 driving measures
  - Both shared spatial resources and response competition negatively impacted driving performance
  - Should amend our conceptualization to include the perceptual code of the conversation as a contributing factor
- Practical applications:
  - Highly spatial conversations have the potential to negatively impact driving performance
  - Tasks that do not require response selection, e.g., listening to driving directions, have the potential to disrupt driving performance
  - Driver training should emphasize that what one talks about on their cell phone can cause performance deficits

# General Discussion

- Future research:
  - Did not measure the resource demand of each task
  - Did not examine differences in participants' ability to image different conversations
  - Some conversations may be easier or more difficult to image based on how abstract they are
    - e.g., a conversation about a football game versus a conversation about governmental regulations on cell phone use

# Questions?

