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Identifying Cognitive Load from Naturalistic Data

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Project Overview – "Cognito"

- Goal: To develop a methodology that will utilize naturalistic data to identify epochs of cognitive activity during driving (using indicators based on eye behavior)
- Project outline (Phase 1)
  - Identify an appropriate naturalistic database for Phase 1 use
  - Extract epochs of cognitive activity and comparison epochs
  - Reduce data from these epochs for glance and blink rate data
  - Merge resulting metrics into a combined dataset
  - Explore the combined data to determine if proposed metrics discriminate types of driver workload and can be used for 'Cognito' algorithm
  - Perform formal analyses to confirm metric validity for 'Cognito' algorithm

"Cognito" Concept

Epochs of high cognitive workload are associated with -- and can be identified -- by:

+

+

Drops in Blink Rate Below Baseline and Comparison Rates

Long Glances to Forward Roadway (>5 sec)

Spatial distribution of glances (many glances on forward road and fewer glances to locations outside of forward road center)

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Original Data Collection Properties

- Two vehicles were used
- A total of 17 participants, ages 27 to 57
- Each participant used the assigned car during their daily routine for ~4 weeks
- Analysts coded eye glance behavior and secondary tasks performed
- Final dataset included:
  - 694 hours of driving
  - 30,371 vehicle-miles

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Types of Activities Studied

- Cognitive epochs (on cell phone)
- Cognitive cell phone conversation baselines
- Visual-Manual task interactions
- Visual-Manual *baseline* comparisons
- Other Cognitive Epochs (Not on Cell Phone)
- Full Baselines

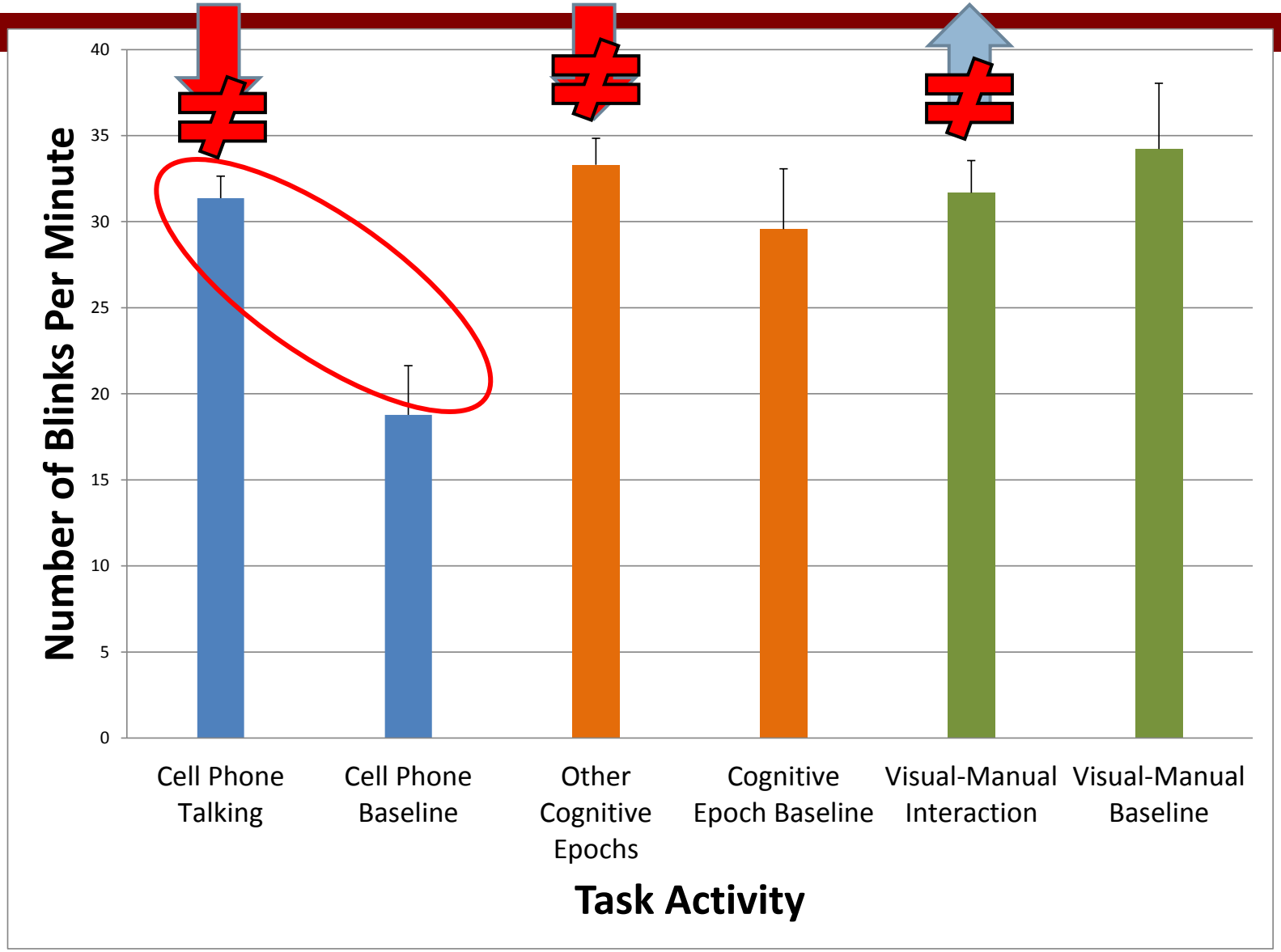
- Conversation (on cell phone)
- "Just driving" (epochs matched in length to cell phone conversations)
- Dialing, radio tuning, changing CD, etc.
- "Just driving" (epochs matched in length to visual-manual tasks)
- Talking, listening (to passenger or self), singing…
- "Just driving" without any secondary tasks at all (at least 1-minute long to match cognitive epochs)

Results from Exploratory Analyses

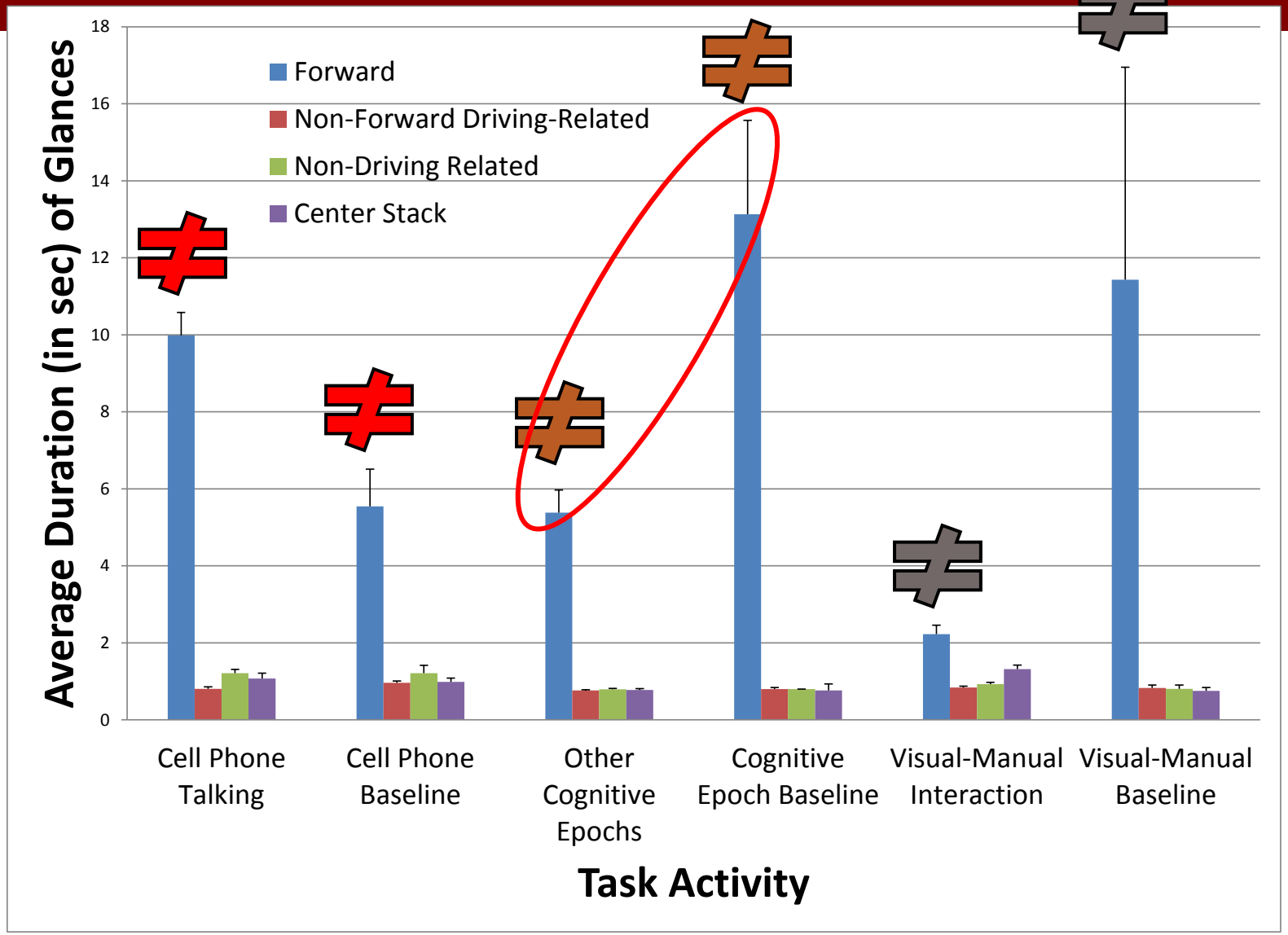
Initial Analysis Approach

- Main variables were tested independently using a mixed linear model with repeated measures
  - The predictors were the six categories of cognitive distraction / baseline condition
  - Driver treated as a random effect

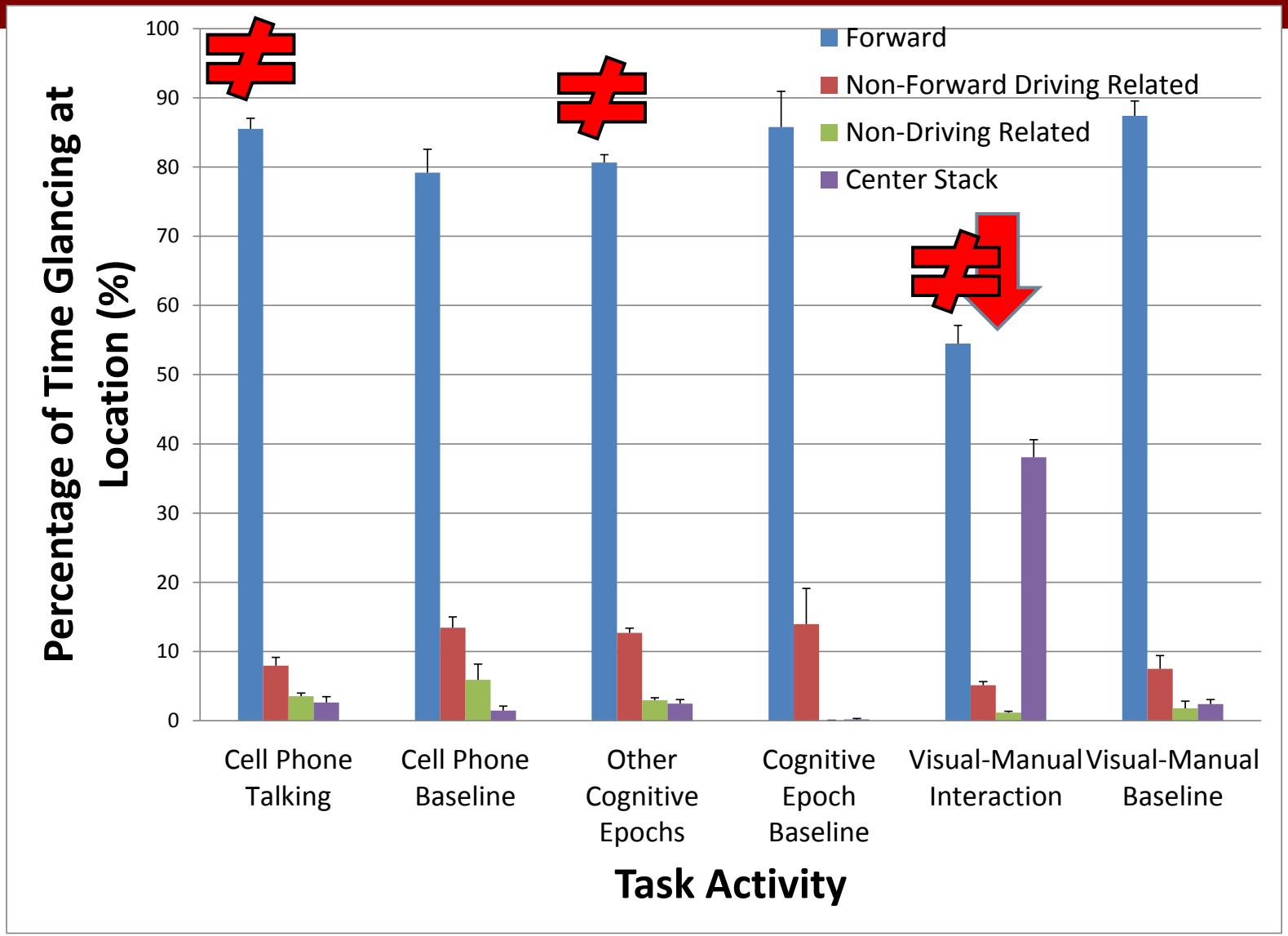
Blink Rate


Number of Blinks Per Minute
40
35
30
25
20
15
10
5
0
Cell Phone Talking
Cell Phone Baseline
Other Cognitive Epochs
Cognitive Epoch Baseline
Visual-Manual Interaction
Visual-Manual Baseline
Task Activity

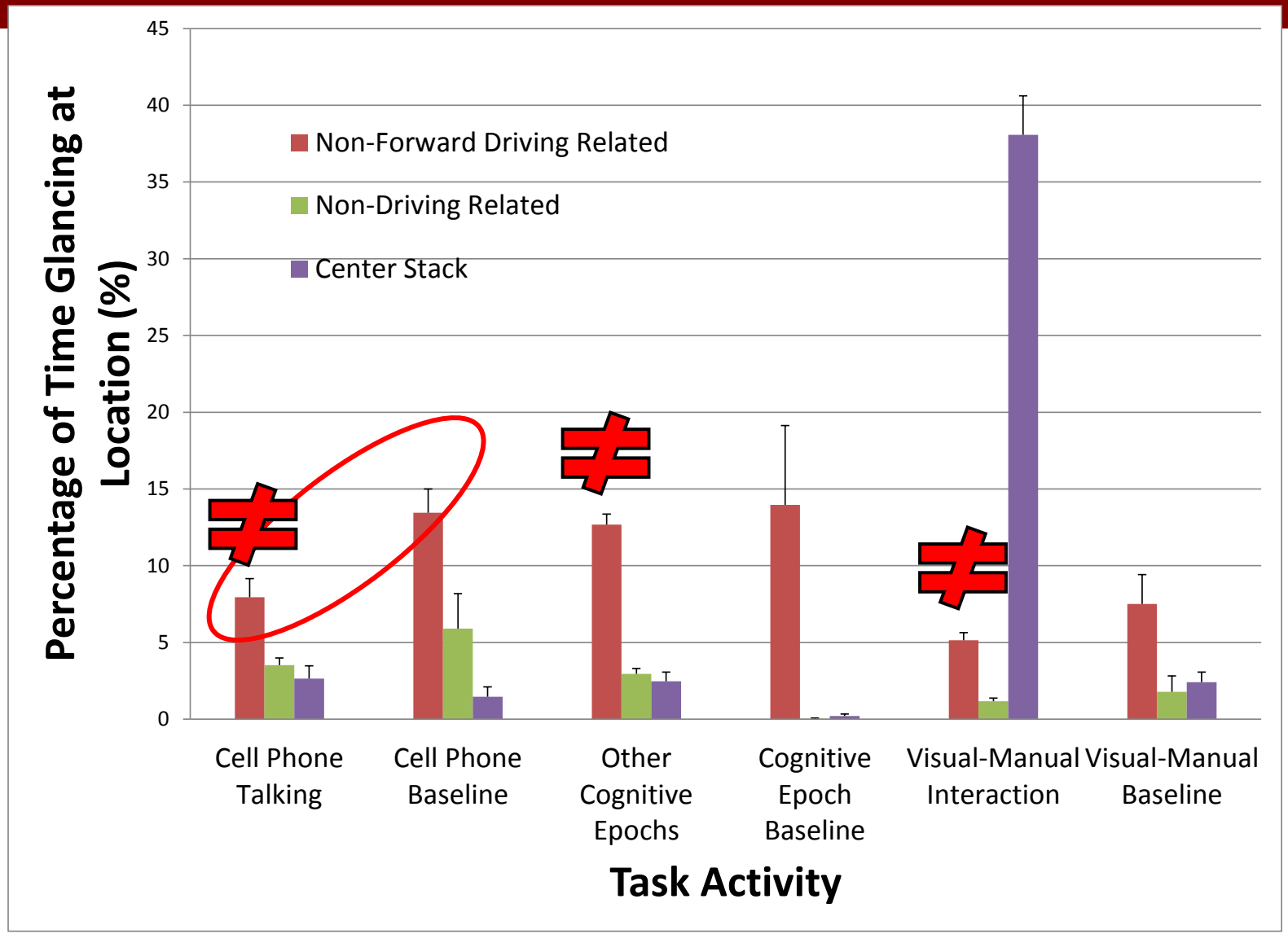
Average Glance Durations



Glance Distribution



Glance Distribution



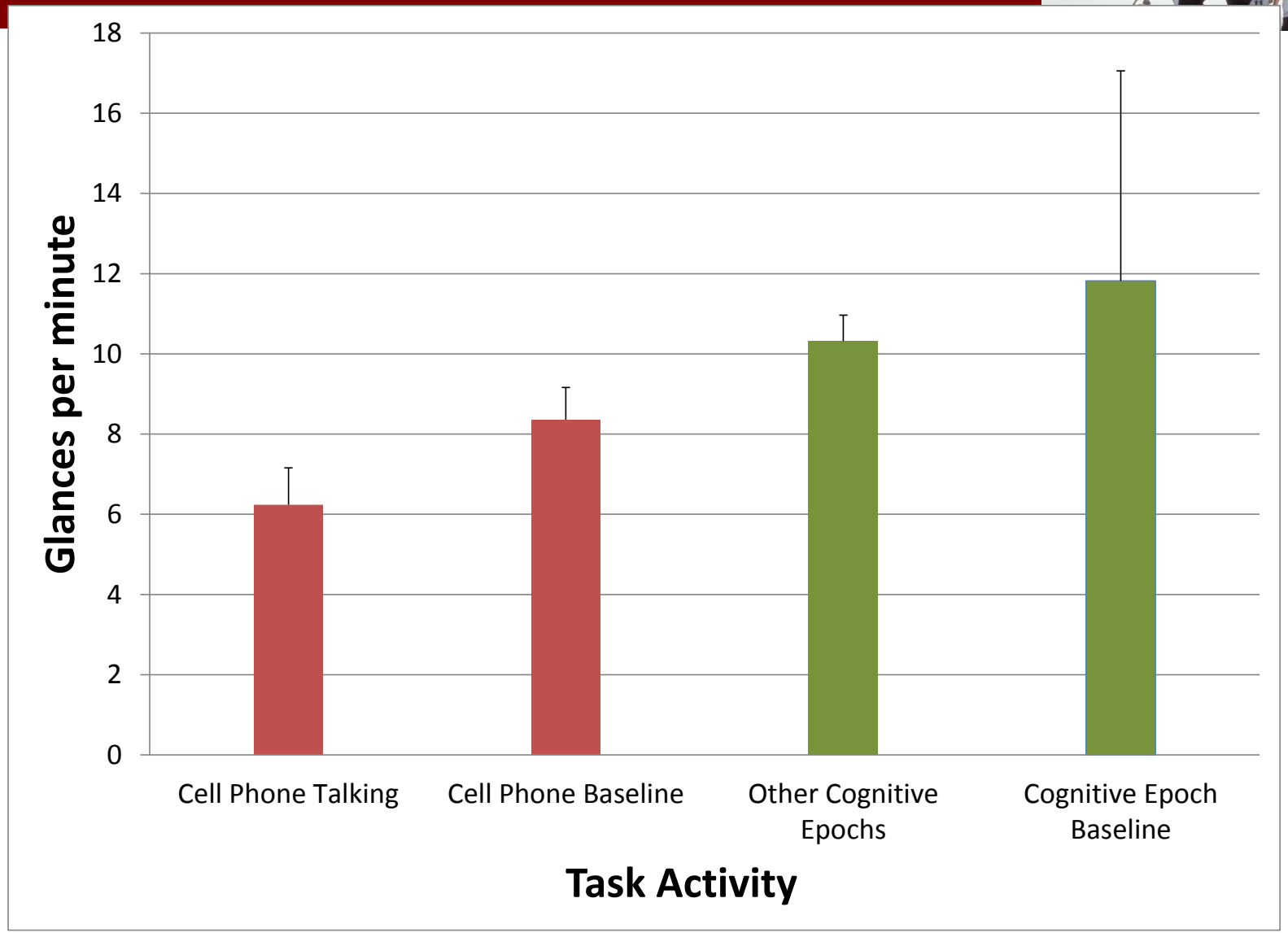
Variables that Change in Mean Value Across Cognitive Epochs/Baseline Epochs

- Number of Glances Forward
- Number of Glances Non-Forward Driving Related
- Number of Glances Non-Forward Non-Driving Related
- Number of Glances Center Stack
- Percent Number of Glances Non-Forward Driving Related
- Percent Number of Glances Non-Forward Non-Driving Related
- Glance Rate Non-Forward Driving Related
- Glance Rate Non-Forward Non-Driving Related
- Glance Rate Center Stack
- Total Duration of Glances Forward
- Total Duration of Glances Non-Forward Driving Related
- Total Duration of Glances Non-Forward Non-Driving Related
- Total Duration of Glances Center Stack
- Percent Duration of Glances Center Stack
- Percent Over 2 Seconds of Glances Forward
- Percent Over 2 Seconds of Glances Center Stack
- Longest Duration of Glances Center Stack Glance
- Number of Eyes Open
- Number of Blinks
- Total Duration of Eyes Open
- Total Duration of Blinks
- Number of Transitions

Model to Predict Task Activity Type (baseline or cognitive)

- Modeled the probability that an epoch had cognitive distraction behaviors
  - Cell phone talking and Other cognitive epochs were marked as cognitive epochs (1)
  - Epochs without any observable distractions (cognitive or otherwise) were marked as baseline epochs (0)
- Driver treated as a random effect
- Logistic regression approach
  - Backwards regression method used to choose variables

Glance Rate
Non-Forward Driving Related



Concluding Remarks

- The data showed some trends and significant results, but they don't appear to tell the whole story
- Non-significant and unexpected differences may be due to a number of reasons
  - Lack of a reliable way to isolate true epochs of very low cognitive distraction
  - Small sample size
  - Very variable environmental context
- Some measures show promise
  - Blink rate behaved opposite to what was expected
  - Glance rate to non-forward but driving-related locations had the highest predictive power

Thanks!

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