Strategies and Performance in an Orientation Task*

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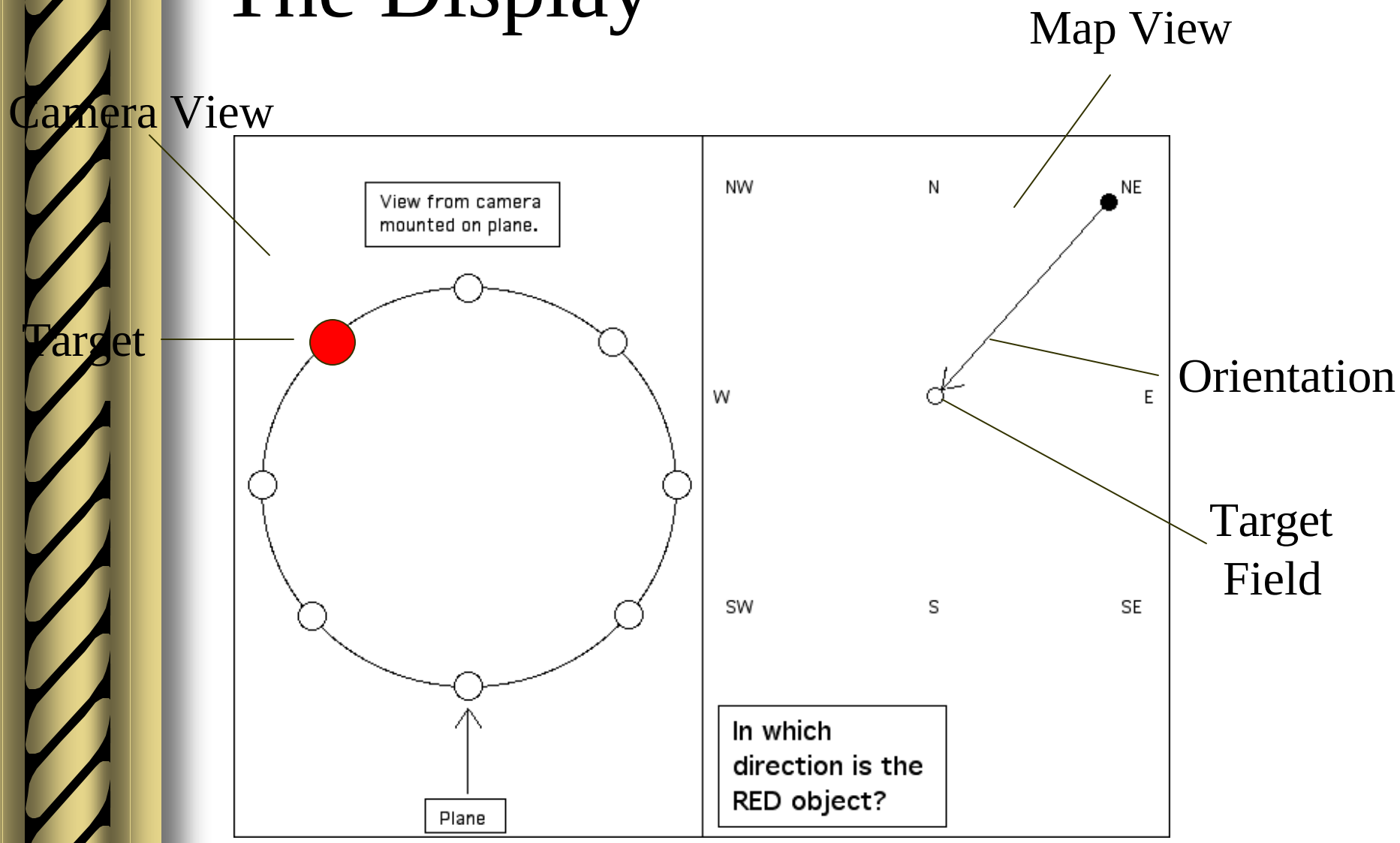
*A version is also to be presented at Cognitive Science 2002; the paper is available through the Cognitive Science Society or ACT-R websites

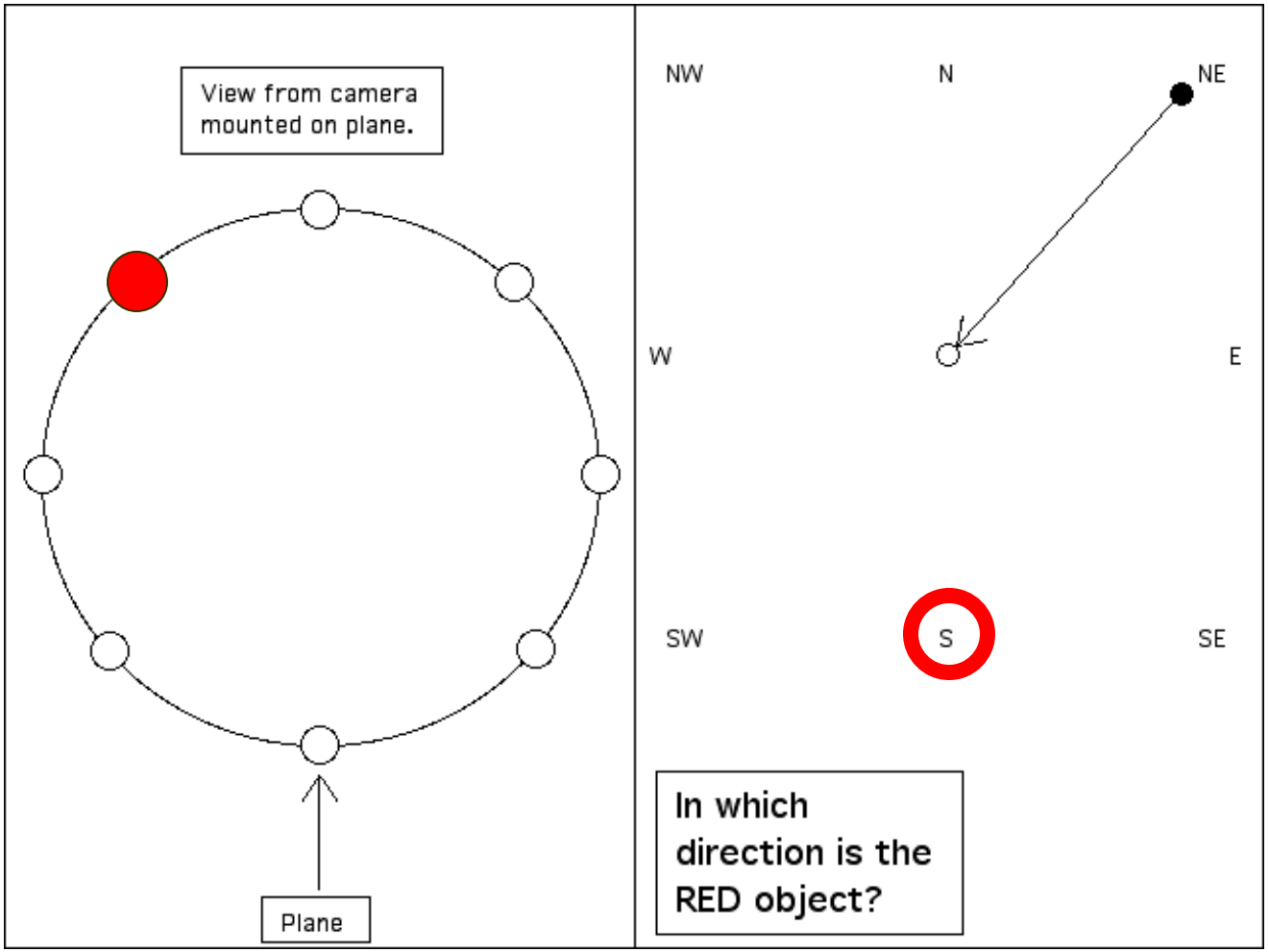
Issues

- **Theories of orientation have relied on imagery and mental rotation**
- **Push ACT-R along the track (along with others) of being able to do spatial reasoning, navigation, etc.**

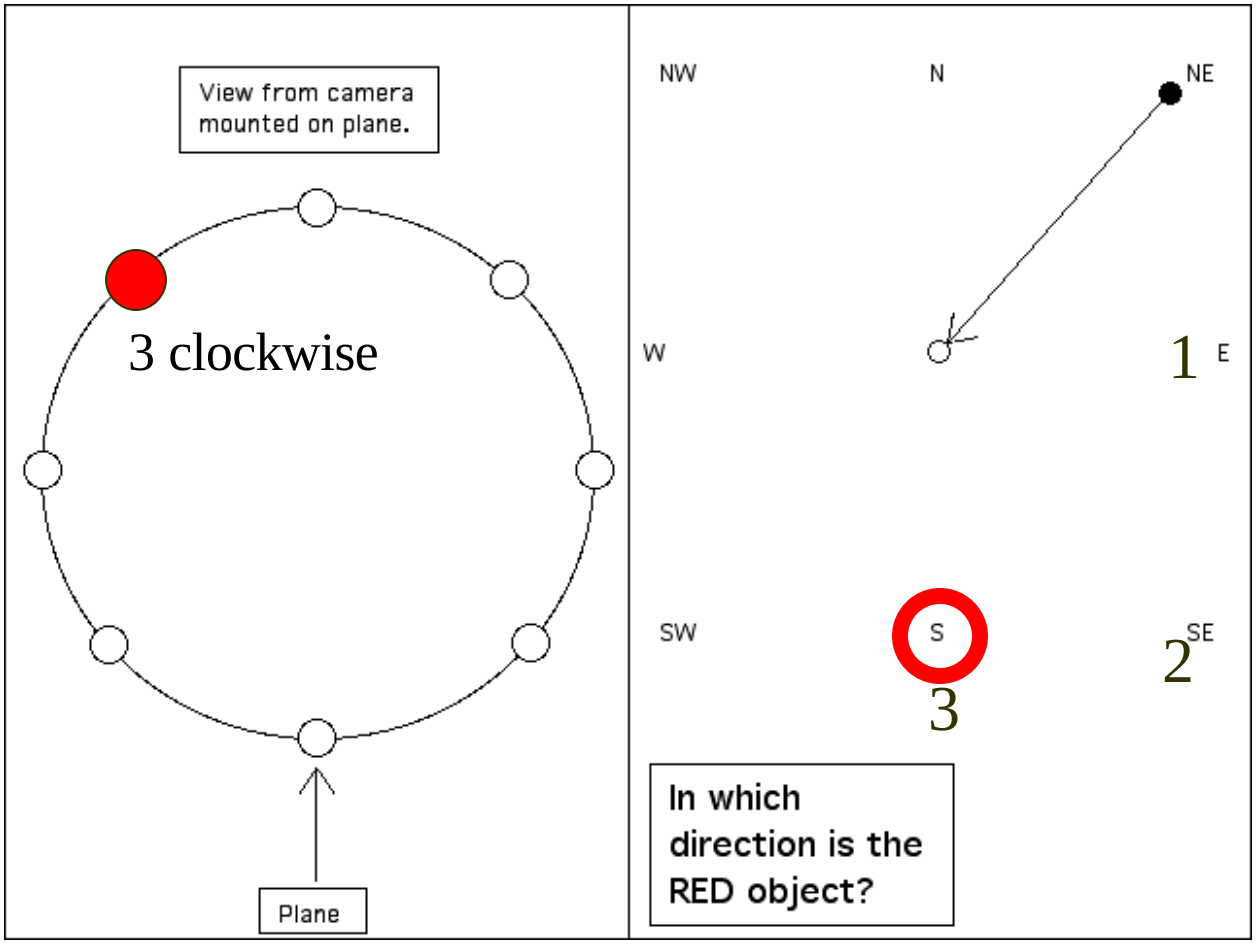
The Display


Map View
Camera View
Target
Orientation
Target Field
View from camera mounted on plane.
NW
N
NE
W
E
SW
S
SE
Plane
In which direction is the RED object?

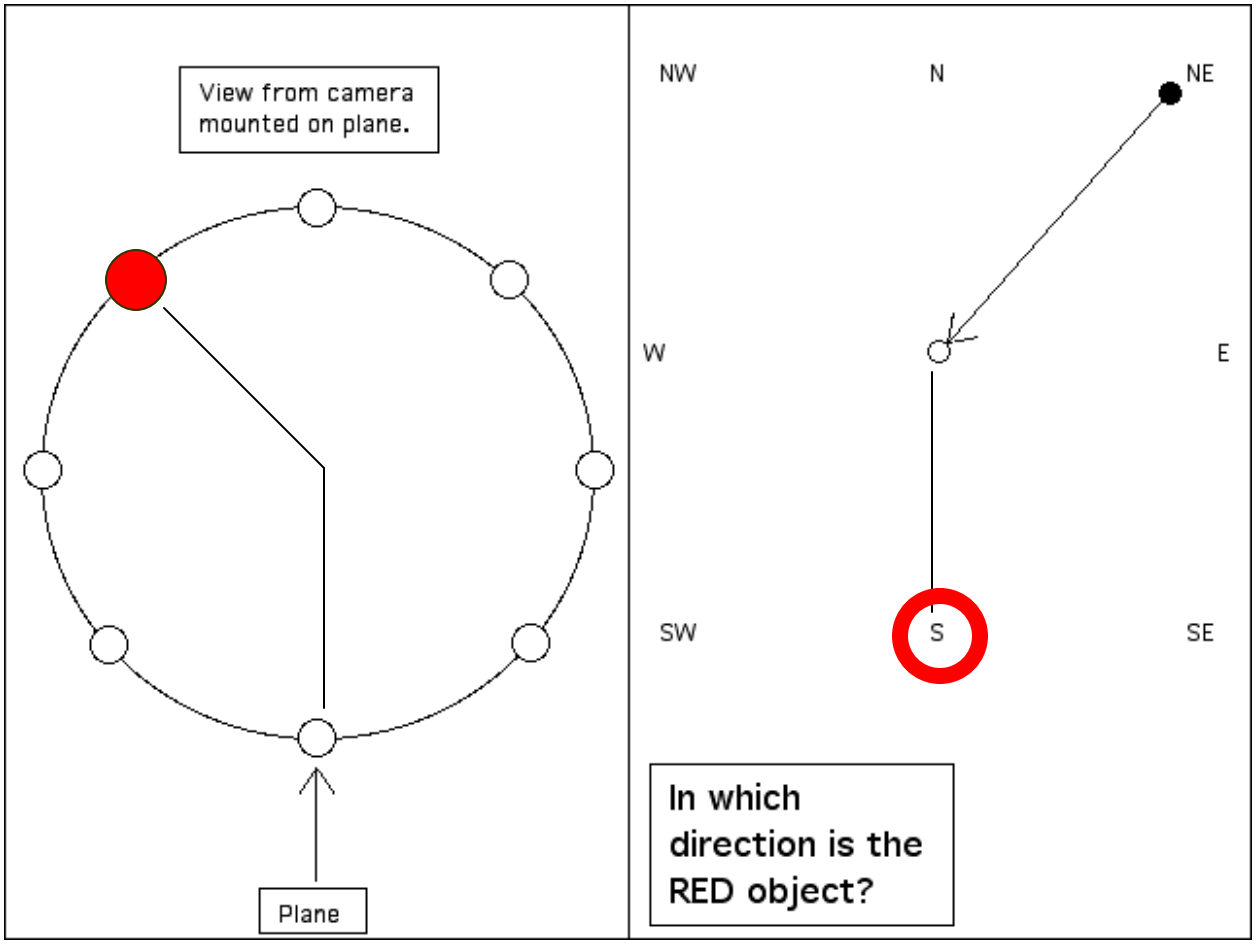
Sample Trial



Counting Strategy



Angle (Rotation) Strategy



Hypotheses

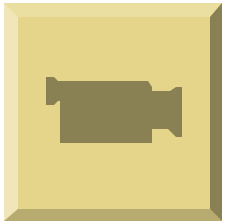
- **Counting Strategy**
  - **Linear effect of target location**
  - **No effect of orientation**
- **Angle Strategy**
  - **No effect of target location**
  - **Linear effect of orientation**

Experiments Two & Three

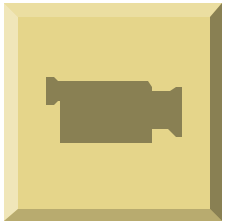
- **Participants...**
  - **Were trained to use one of the two strategies**
  - **Completed 4 blocks of trials**
    - **All 64 possible trials were presented using a dropout procedure**
- **Reliable differences found between strategies**
- **Experiment 3 - Eye Tracking**

Movies

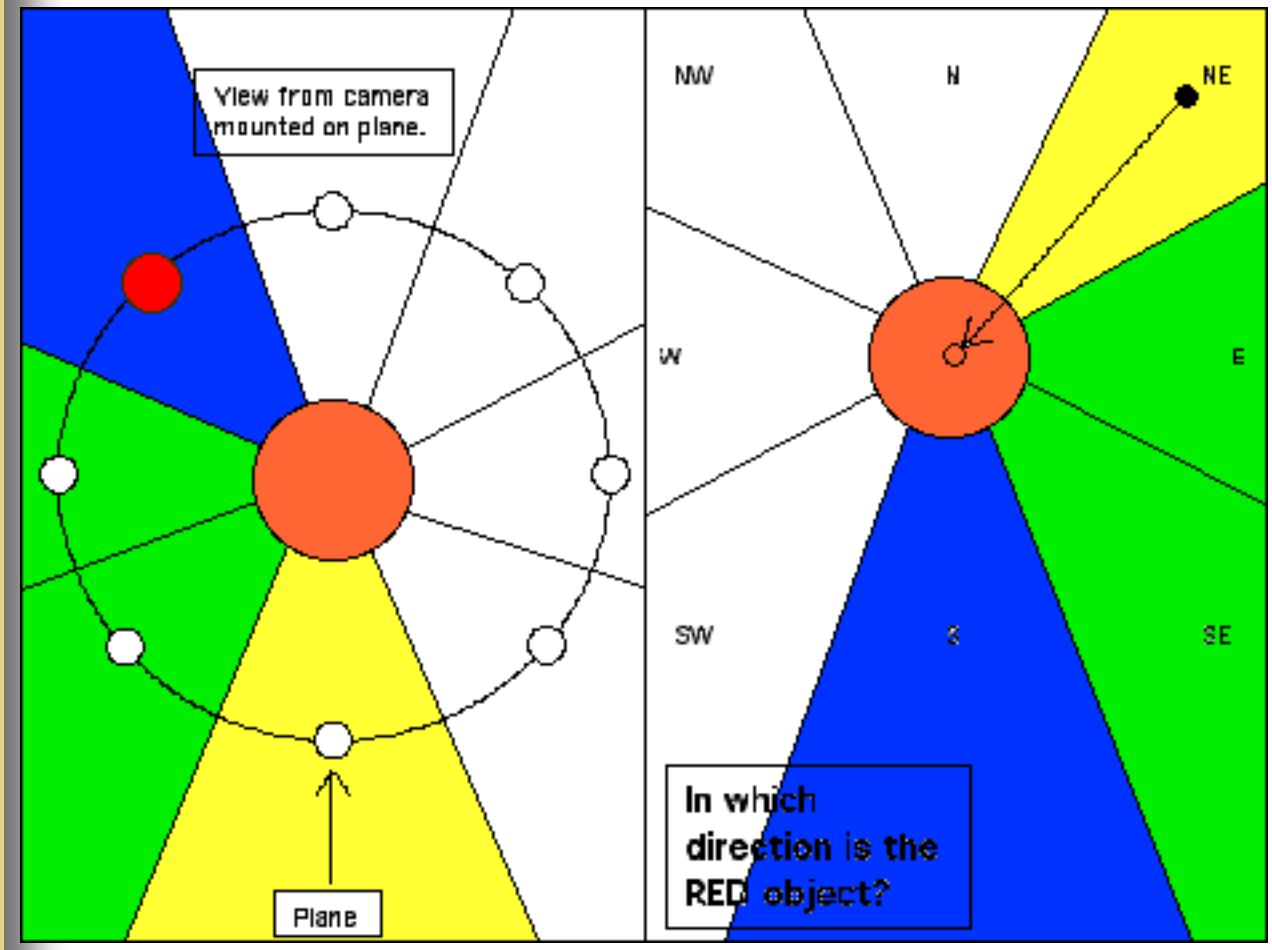
Counting



Angle



Eye Data Regions



Target

Plane

Center

Between

Other

The Eye Data

- **Counting Strategy**
  - **More time spent looking at regions between the plane and the target on both views**
- **Angle Strategy**
  - **More time spent looking at the center of the views, particularly on the map**

An ACT-R 5.0 Model

- **ACT-R 5.0 includes perceptual and motor modules that are closely tied to the cognitive component**
  - **The ACT-R model can *actually do* the task**
- **Simply an instantiation of the proposed strategies**
  - **Explanations can be quantified to see if they fit with the data**

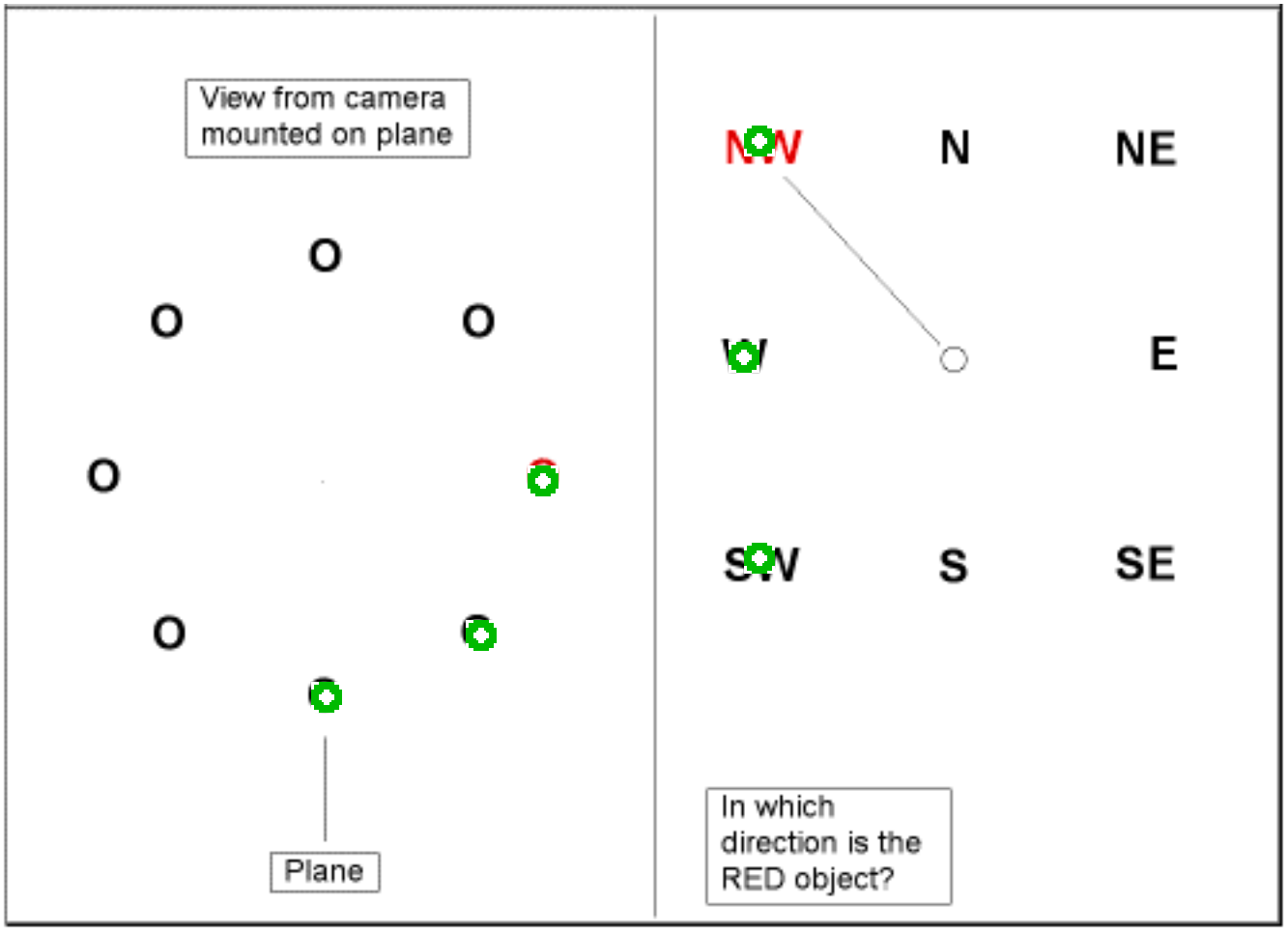
Special-case Strategies

- **Included for**
  - **Target locations of 0 or 180 degrees**
    - **These were reported by participants in both conditions**
  - **Plane locations of South (counting strategy)**

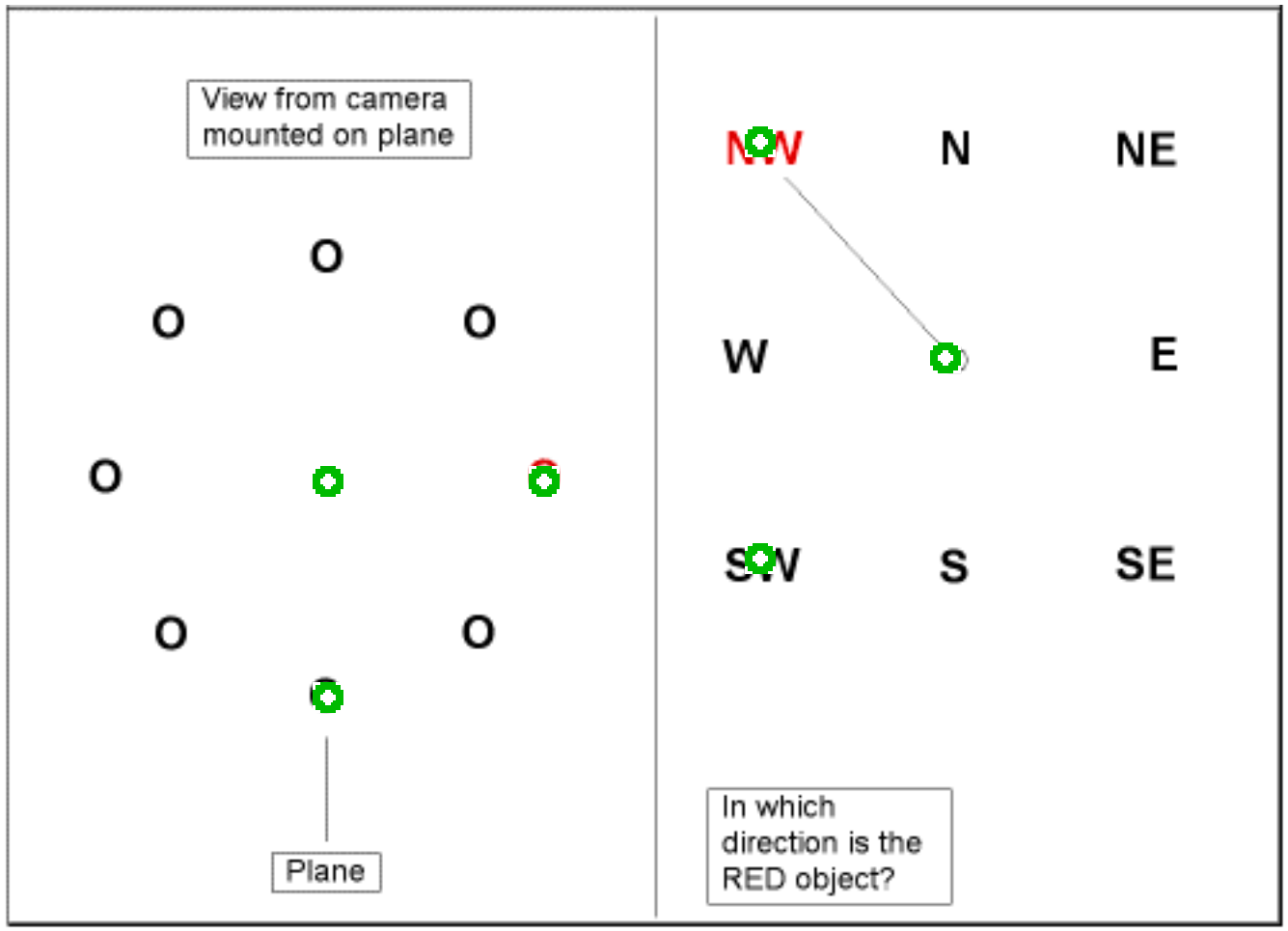
Rotation in Angle Strategy

- **Model contains an "Imaginal Buffer"**
  - **Holds a chunk that encodes 3 visual locations**
    - **Three angle points**
      - **Encoded on camera view**
      - **"Mentally moved" to the map view**
  - **On map view, rotation consists of iteratively updating the locations of the angle's endpoints**

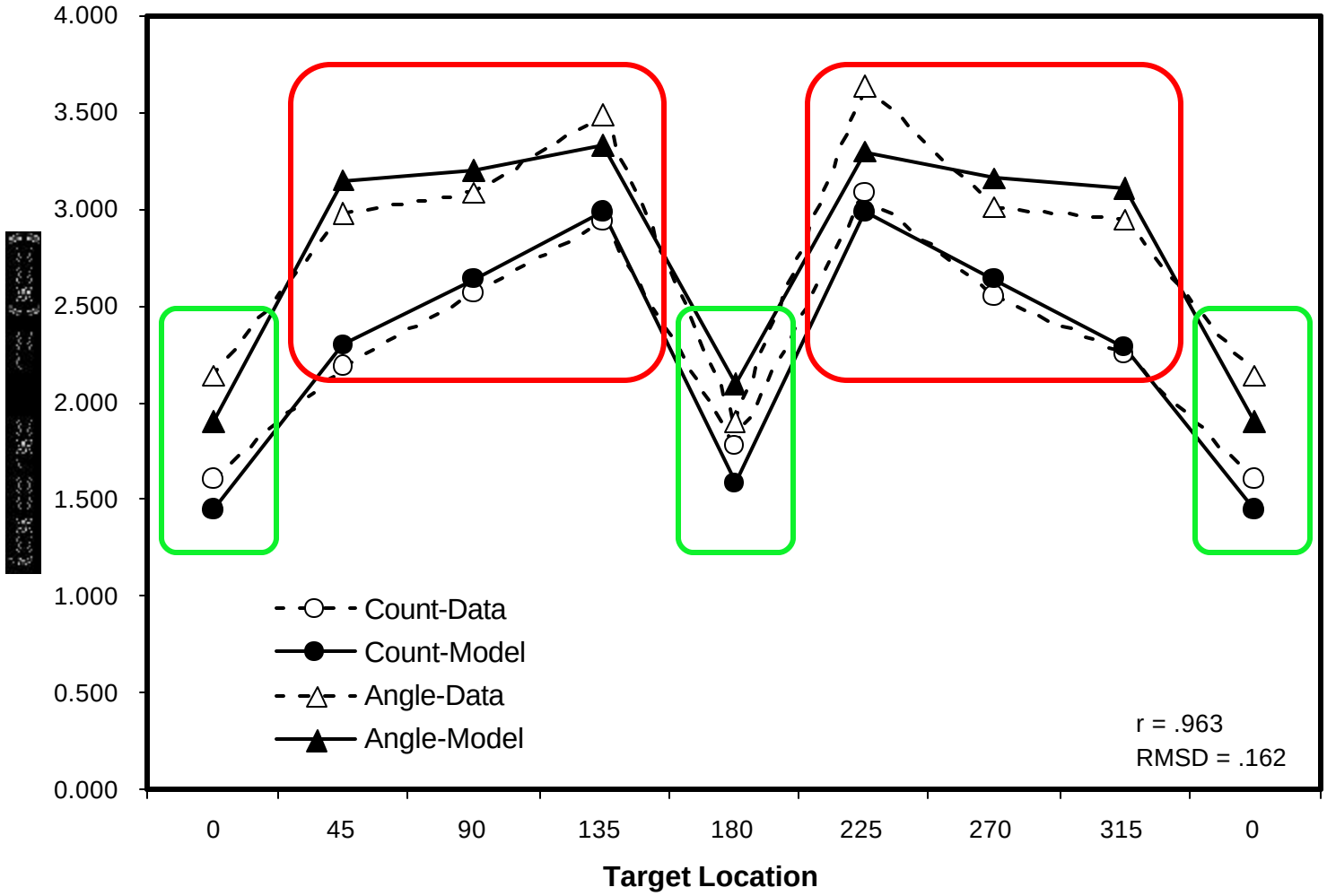
Counting Model



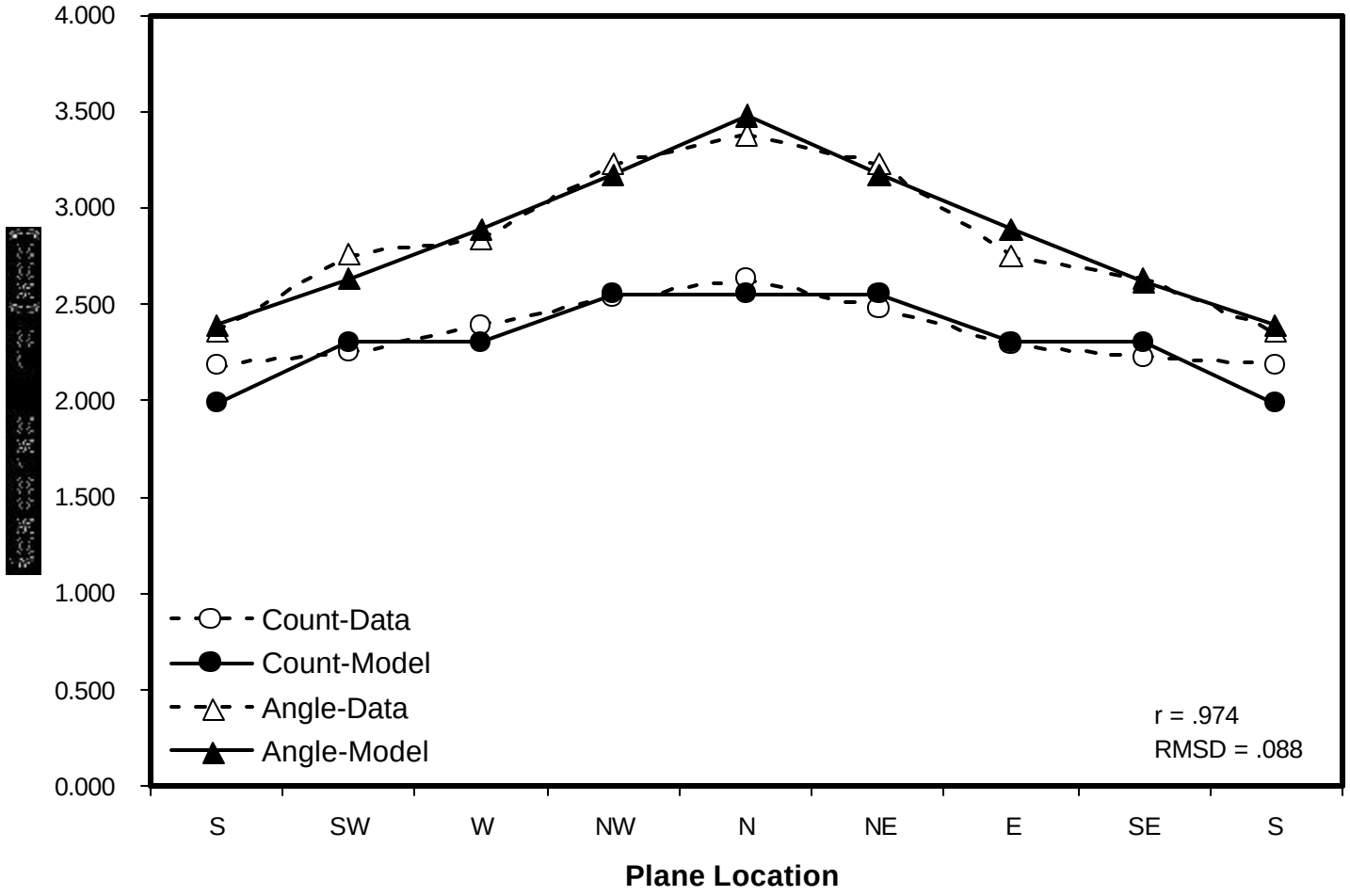
Angle Model


View from camera mounted on plane
Plane
NW
N
NE
W
E
SW
S
SE
In which direction is the RED object?

Model Fit


4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
0
45
90
135
180
225
270
315
0
Target Location
Count-Data
Count-Model
Angle-Data
Angle-Model
r = .963
RMSD = .162

Model Fit


4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
Count-Data
Count-Model
Angle-Data
Angle-Model
r = .974
RMSD = .088
S
SW
W
NW
N
NE
E
SE
S
Plane Location

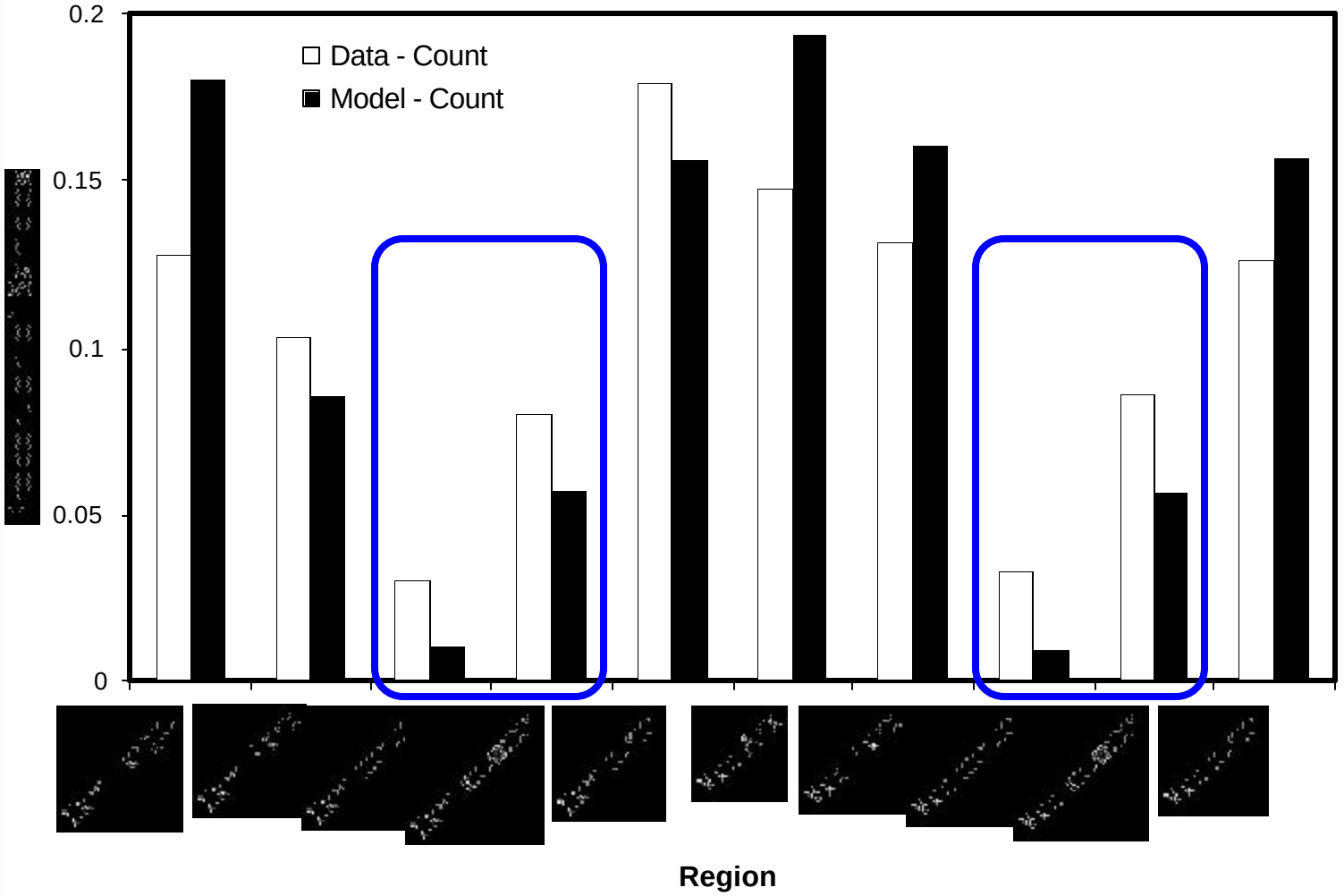
Hypotheses Mostly Supported

- **Small effect of plane angle in counting strategy**
  - **Encode target as left/right instead of clockwise/counterclockwise**
    - **40% of errors were left/right confusions**
      - **(i.e., instances where the answer given was the right deviation from the plane, but in the wrong direction**
- **Effect of target location in angle strategy not fully captured**

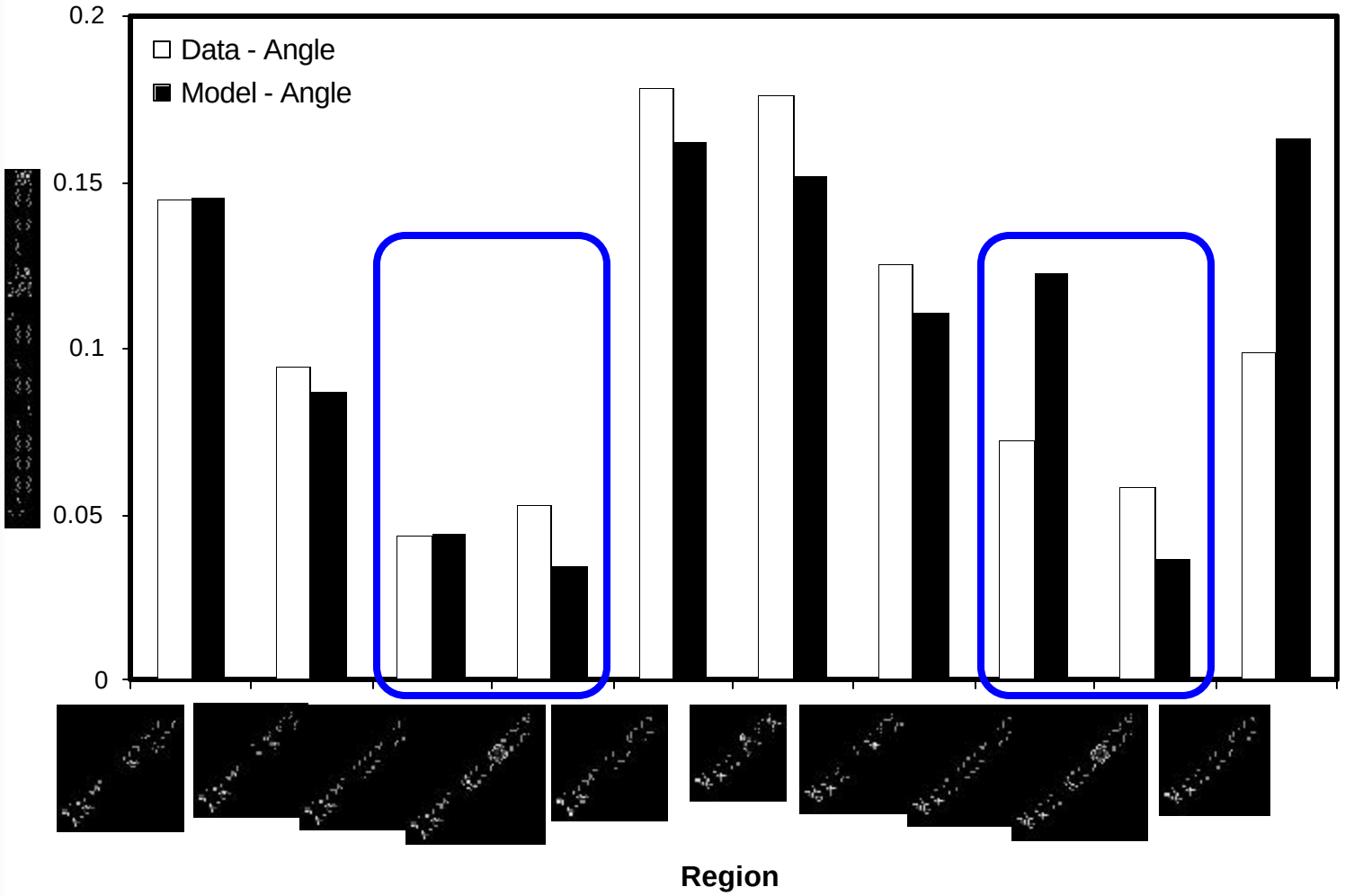
Eye Data

- **Fit involves a single parameter**
  - **Proportion of eye samples that are "on-task"**
    - **Set to .5**
    - **The rest are randomly distributed across the screen**
    - **Several components of "off-task"**
  - **Correlation = .86, RMSD = .03 (3%)**

Eye Data - Counting



Eye Data - Angle



Conclusions

- **The "PM" may help to reduce the number of free parameters**
  - **Only 2 needed here:**
    - **Latency Factor (.1)**
    - **One production execution time (.2)**
- **Strategy variation is fundamental**
  - **More comprehensive accounts**
- **Fine-grained data allow for more accurate accounts**
  - **Predicting eye movements!!**