A Computational Model of Routine Procedural Memory

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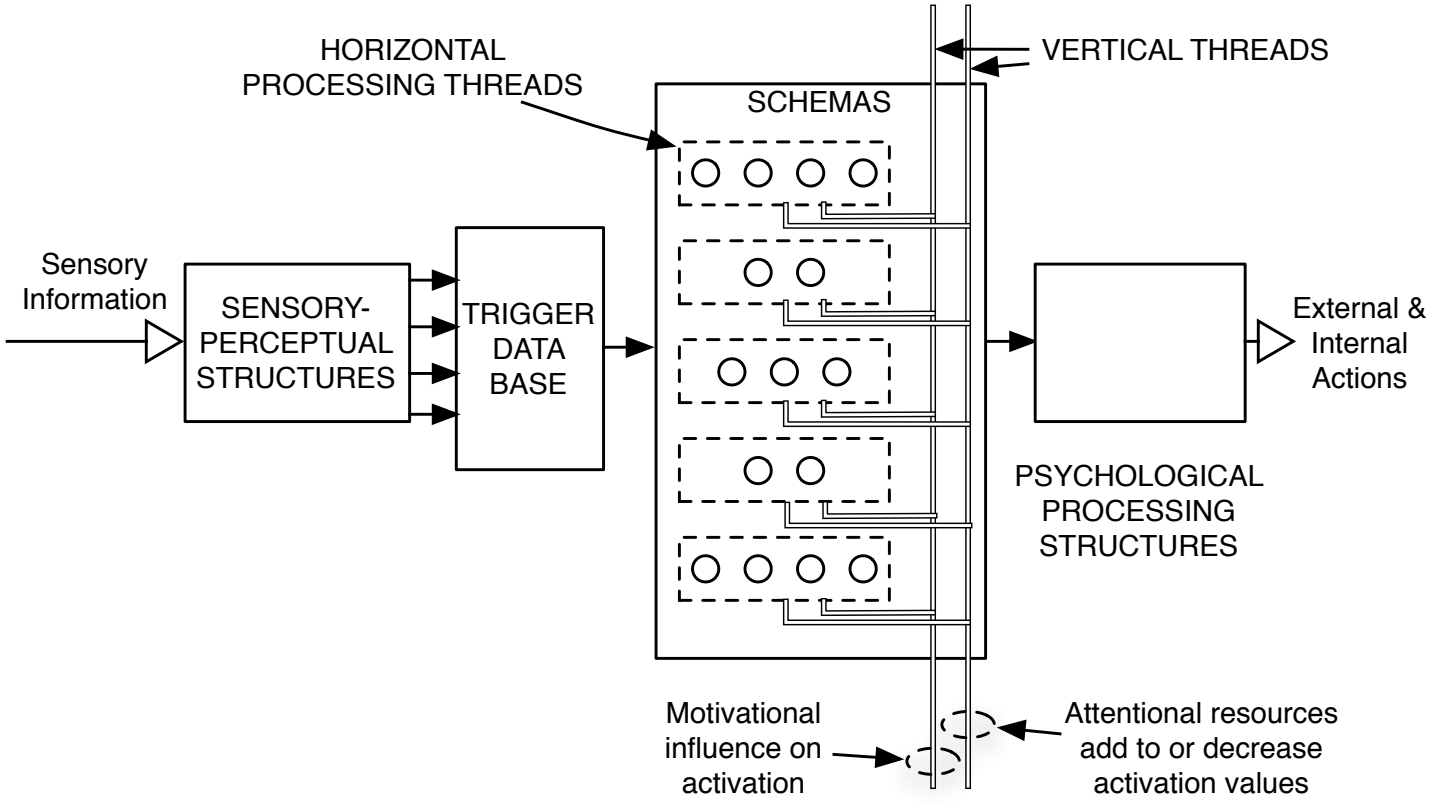
Overview

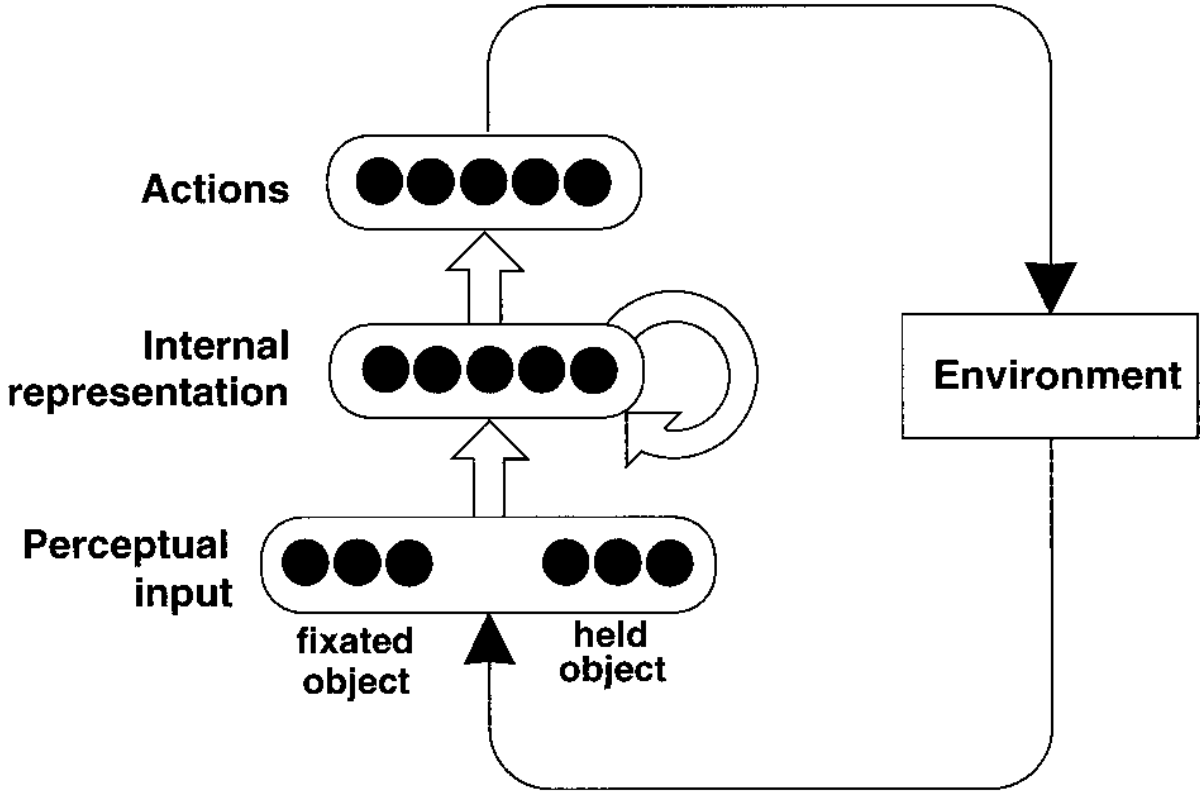
- Very Brief Introduction
- Two Experiments, Very Briefly
- ACT-R Model

Context

Contention Scheduling Model (CSM)



Simple Recurrent Network (SRN)

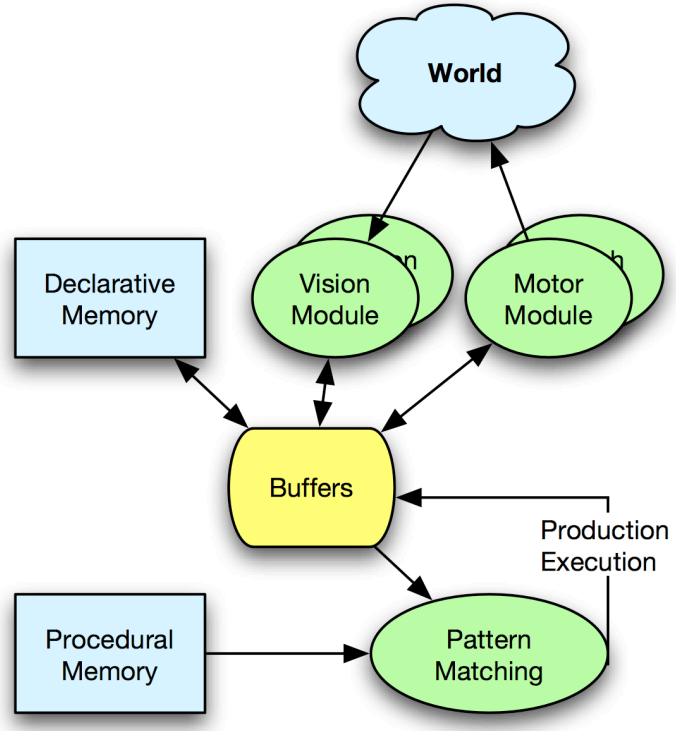


GOMS

- GOAL: EDIT-MANUSCRIPT
  - GOAL: EDIT-SUBTASK *repeat until no more subtasks*
    - GOAL: ACQUIRE-SUBTASK
      - GET-NEXT-PAGE *if at end of manuscript page*
      - GET-NEXT-TASK
    - GOAL: EXECUTE-SUBTASK
      - GOAL: LOCATE-LINE
        - [select: USE-QUOTED-STRING-METHOD
        - USE-LINEFEED-METHOD]
      - GOAL: MODIFY-TEXT
        - [select: USE-SUBSTITUTE-COMMAND
        - USE-MODIFY-COMMAND]
        - VERIFY-EDIT

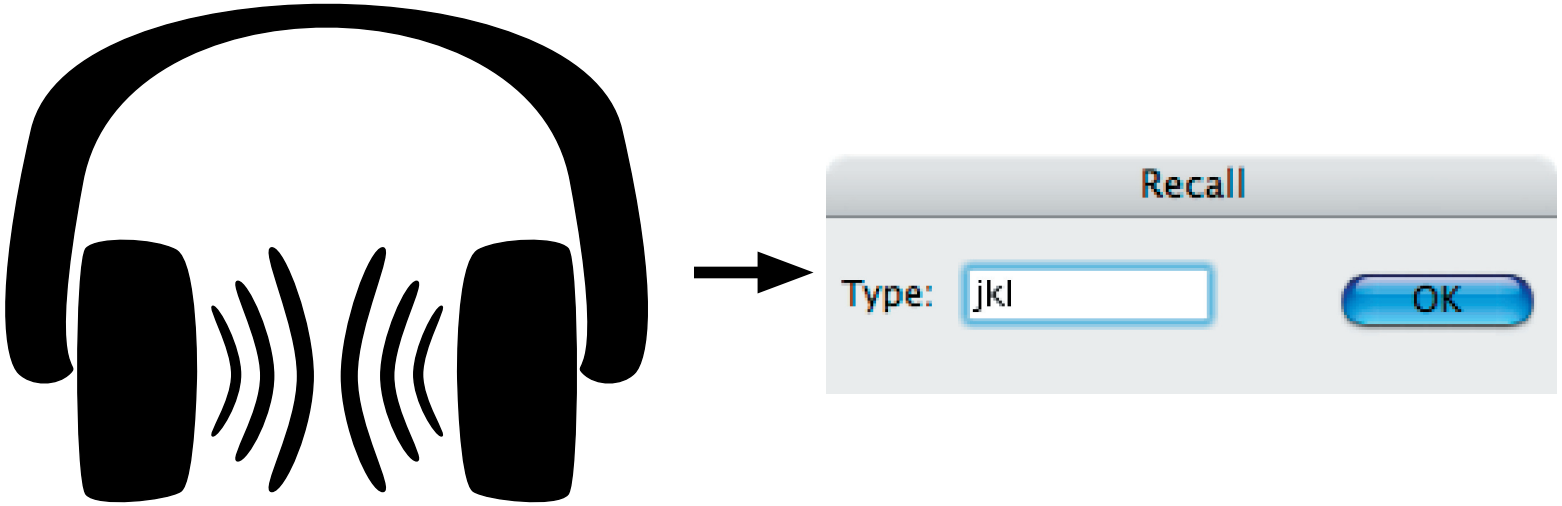
ACT-R

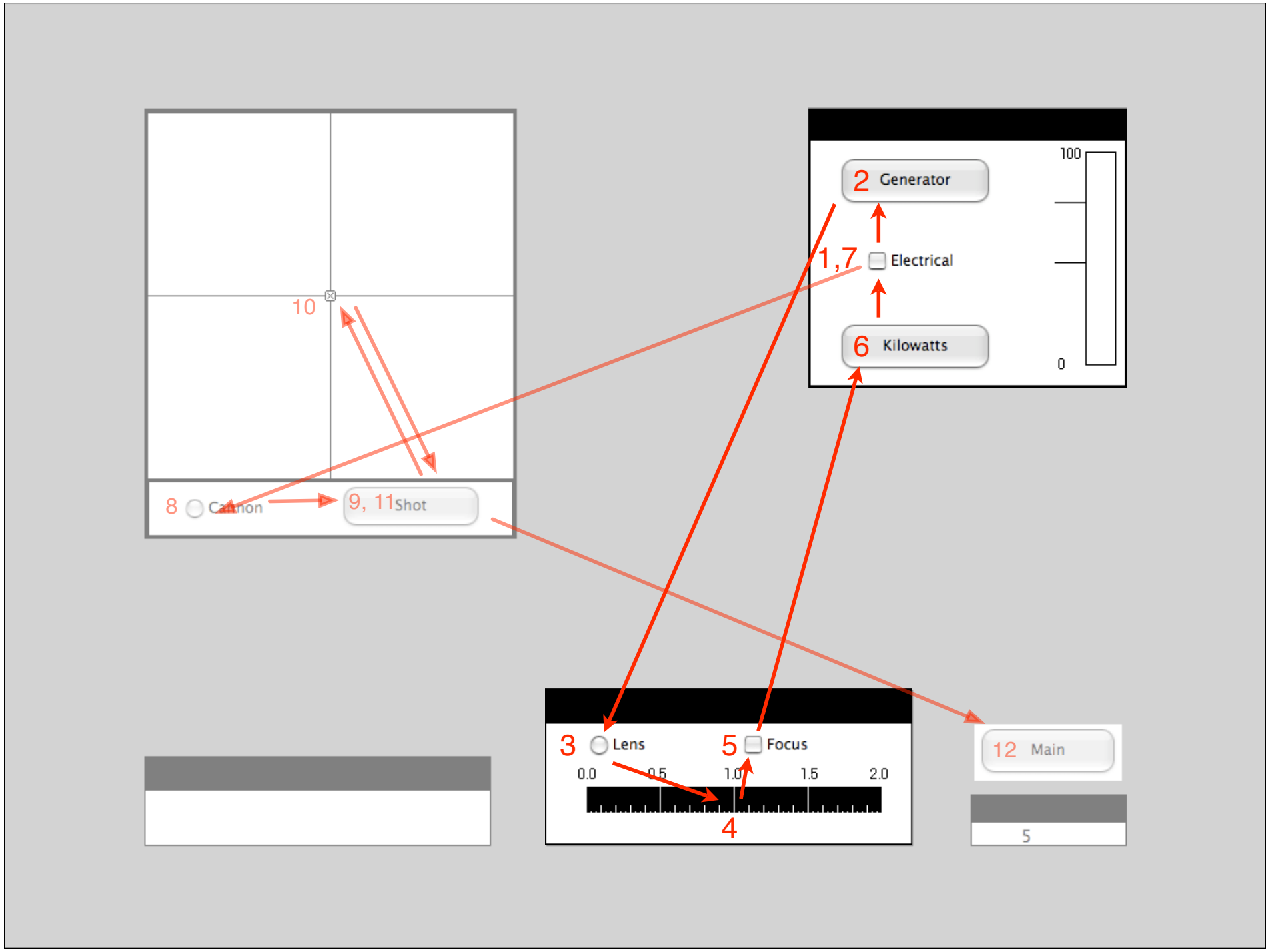
- Inputs:
  - Knowledge
    - IF-THEN rules (termed “productions”)
    - Declarative knowledge (“chunks”)
    - Subsymbolic parameters
  - Simulated task environment/world
- Output: Time-stamped behavior sequence

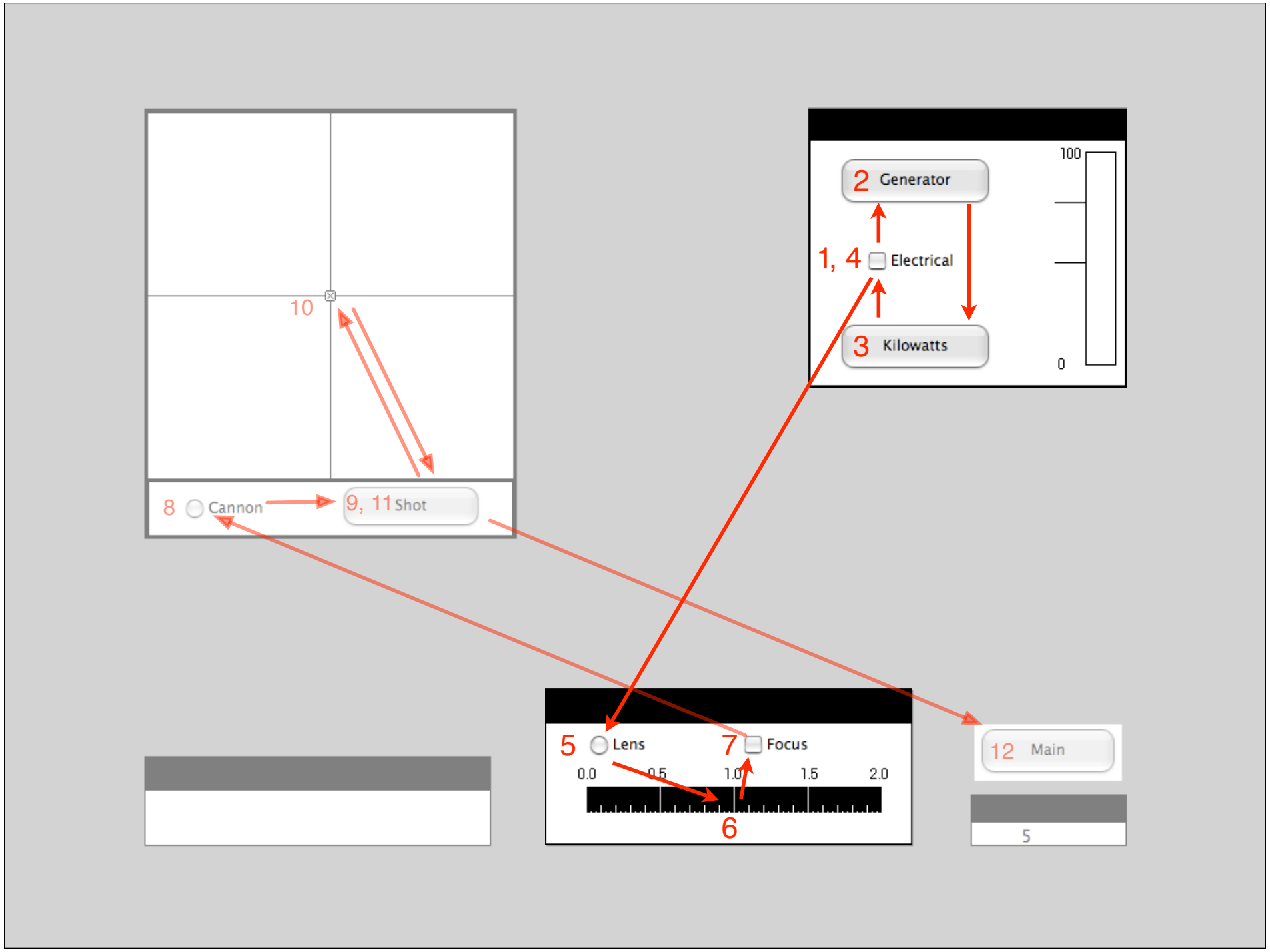


Experiment Overview

- Task is a routine procedure
- Subjects trained approximately one week before
- Concurrent working memory task given




10
8
Cannon
9, 11
Shot
2
Generator
1,7
Electrical
6
Kilowatts
100
0
3
Lens
5
Focus
0.0
0.5
1.0
1.5
2.0
4
12
Main
5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8 Cannon
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1.5
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12 Main
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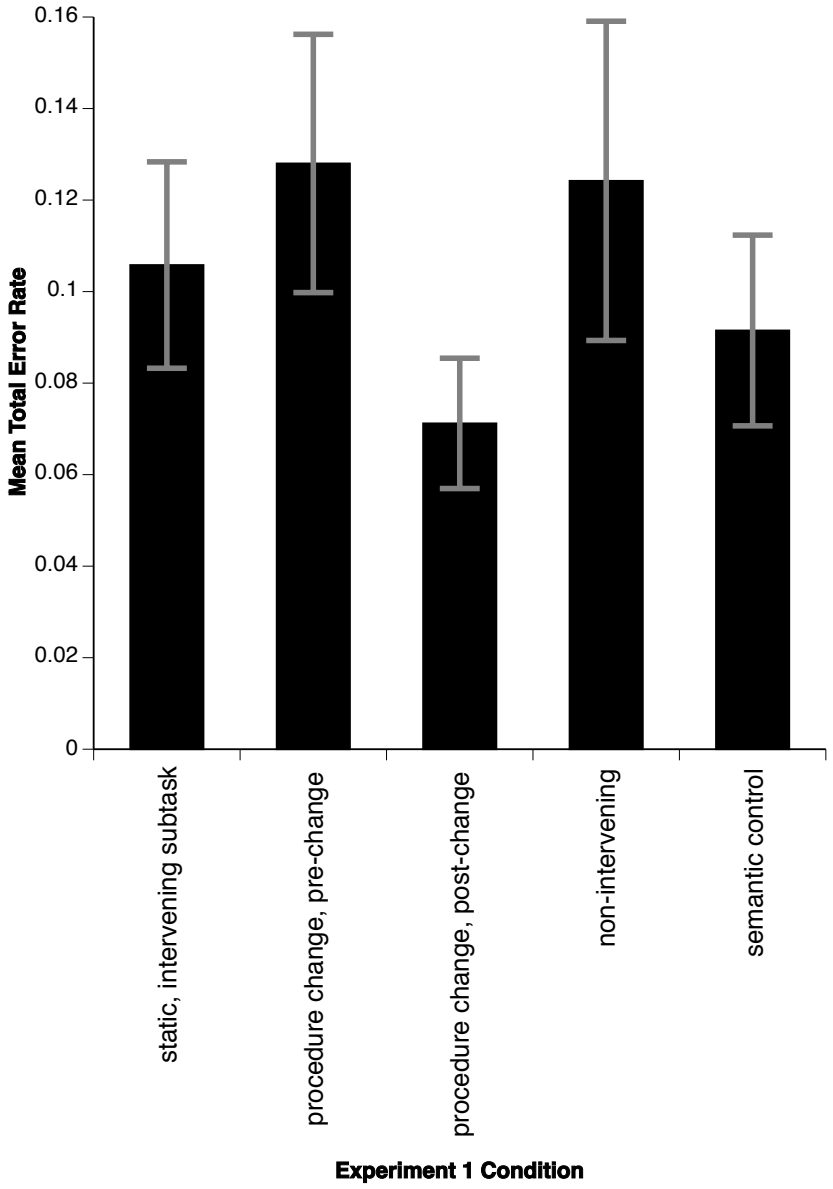
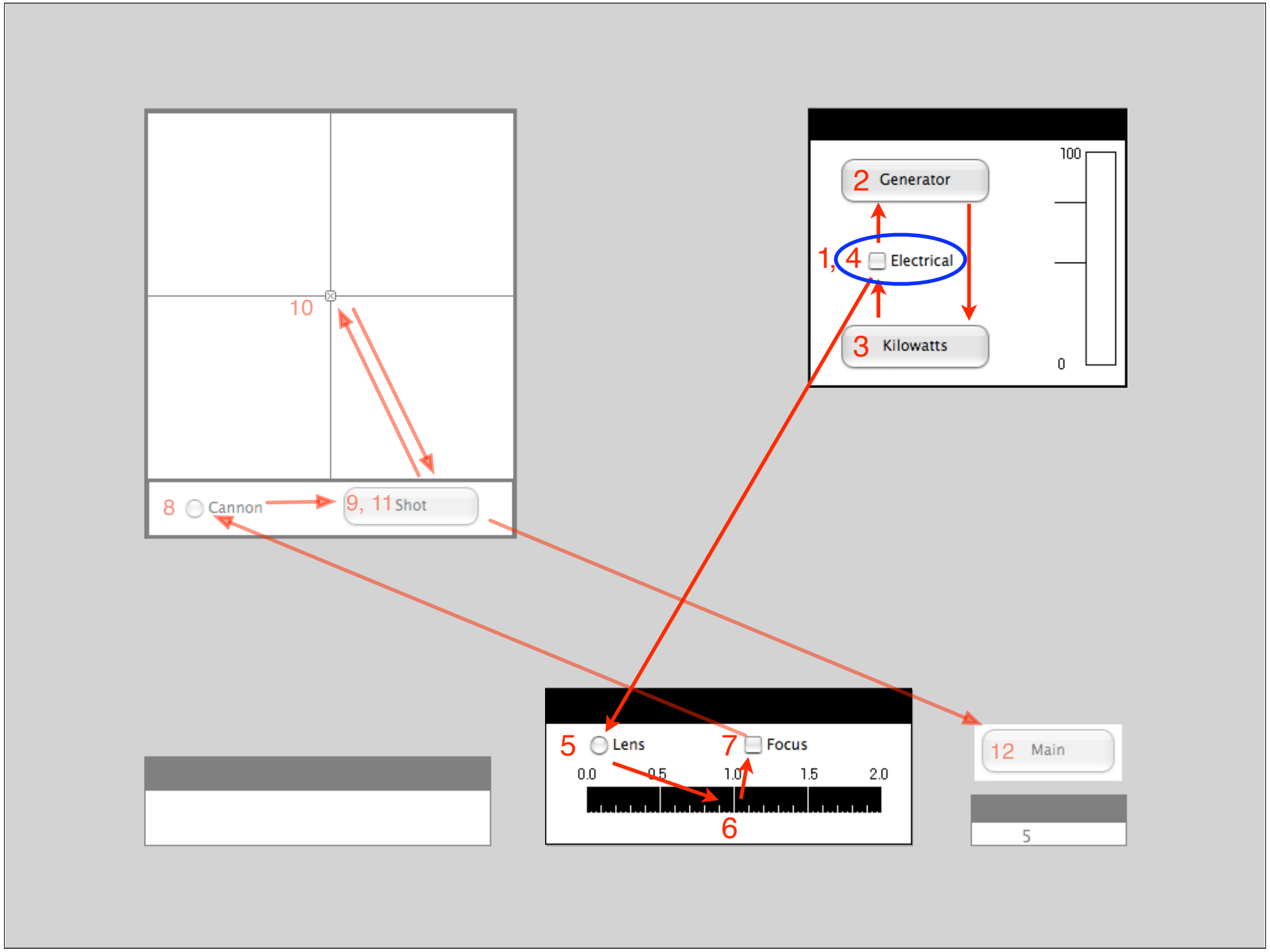

0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Mean Total Error Rate
static, intervening subtask
procedure change, pre-change
procedure change, post-change
non-intervening
semantic control
Experiment 1 Condition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6
12 Main
5

Desynchronize

9, 11 Synchronous Mode

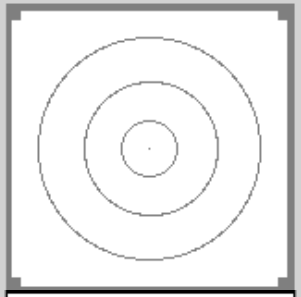
8 Transporter Power
Diagnostic Z
Auxiliary Power

Calibration

5 Enter Frequency

6 0 0

7 Accept Frequency
Accept Calibration
Frequency Sample



1 Scanner On
4 Scanner Off
2 Active Scan
3 Lock Signal
Tracker On
Tracker Off
Modulator
Fix Frequency

10

Status

12 Main Control Diagnostic
Alpha Mask System Lock

Elapsed Time
17

Desynchronize

9, 11 Synchronous Mode

8 Transporter Power
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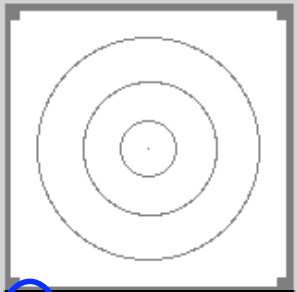
Auxiliary Power

Calibration

5 Enter Frequency

6 0 0

7 Accept Frequency
Accept Calibration
Frequency Sample



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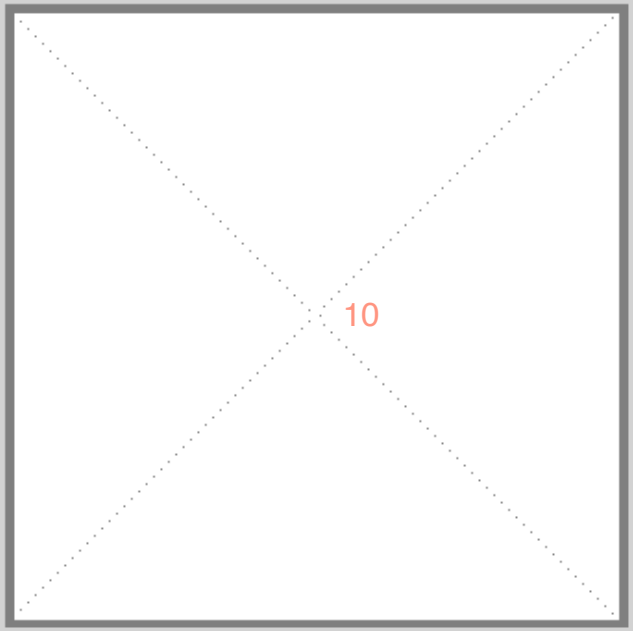
Modulator
Fix Frequency



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Elapsed Time
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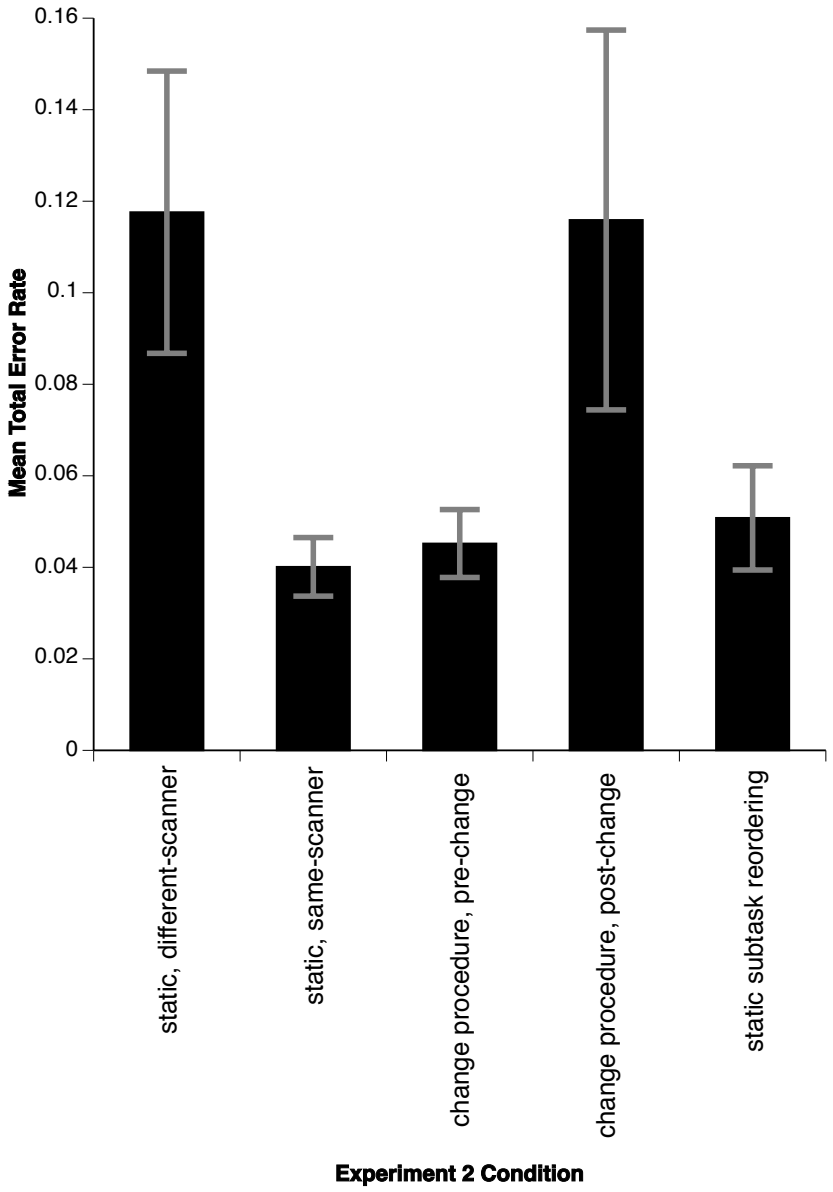
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0.1
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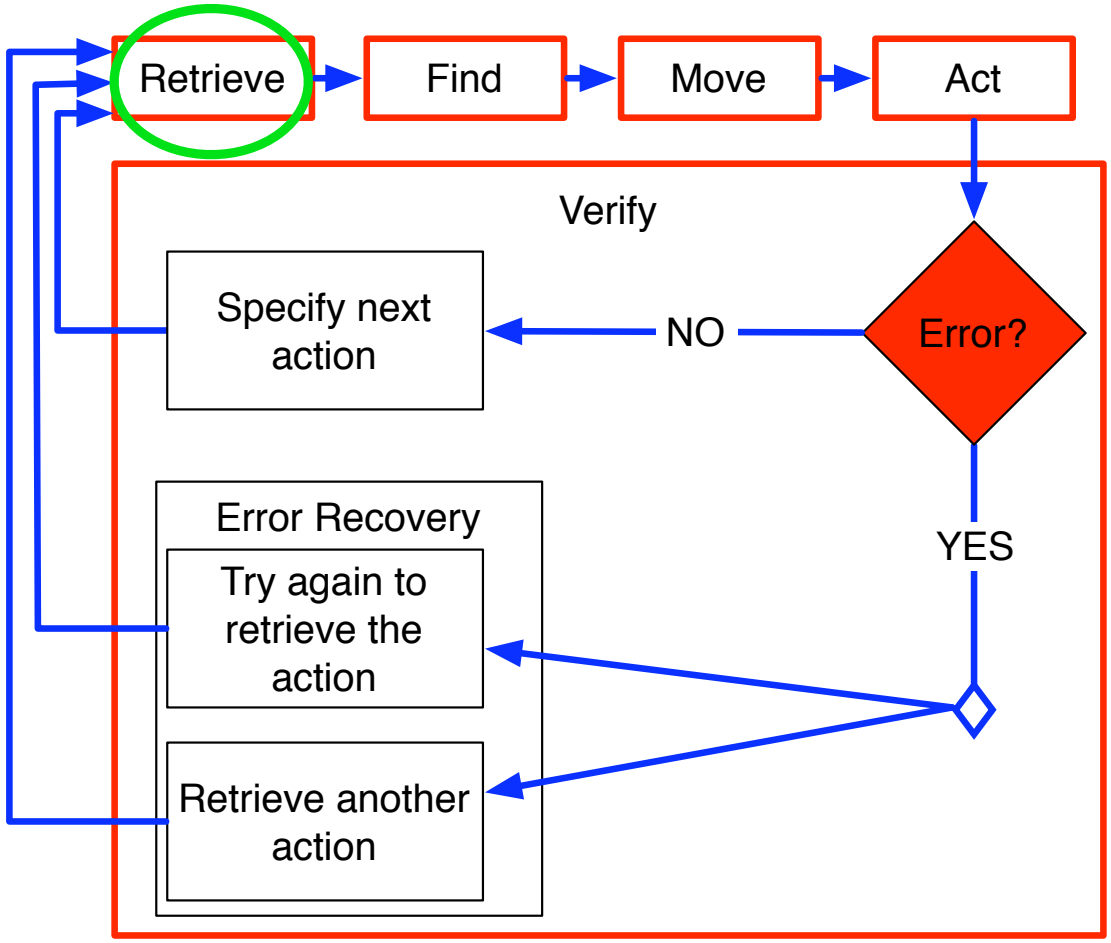
0.02
0
Mean Total Error Rate
static, different-scanner
static, same-scanner
change procedure, pre-change
change procedure, post-change
static subtask reordering
Experiment 2 Condition

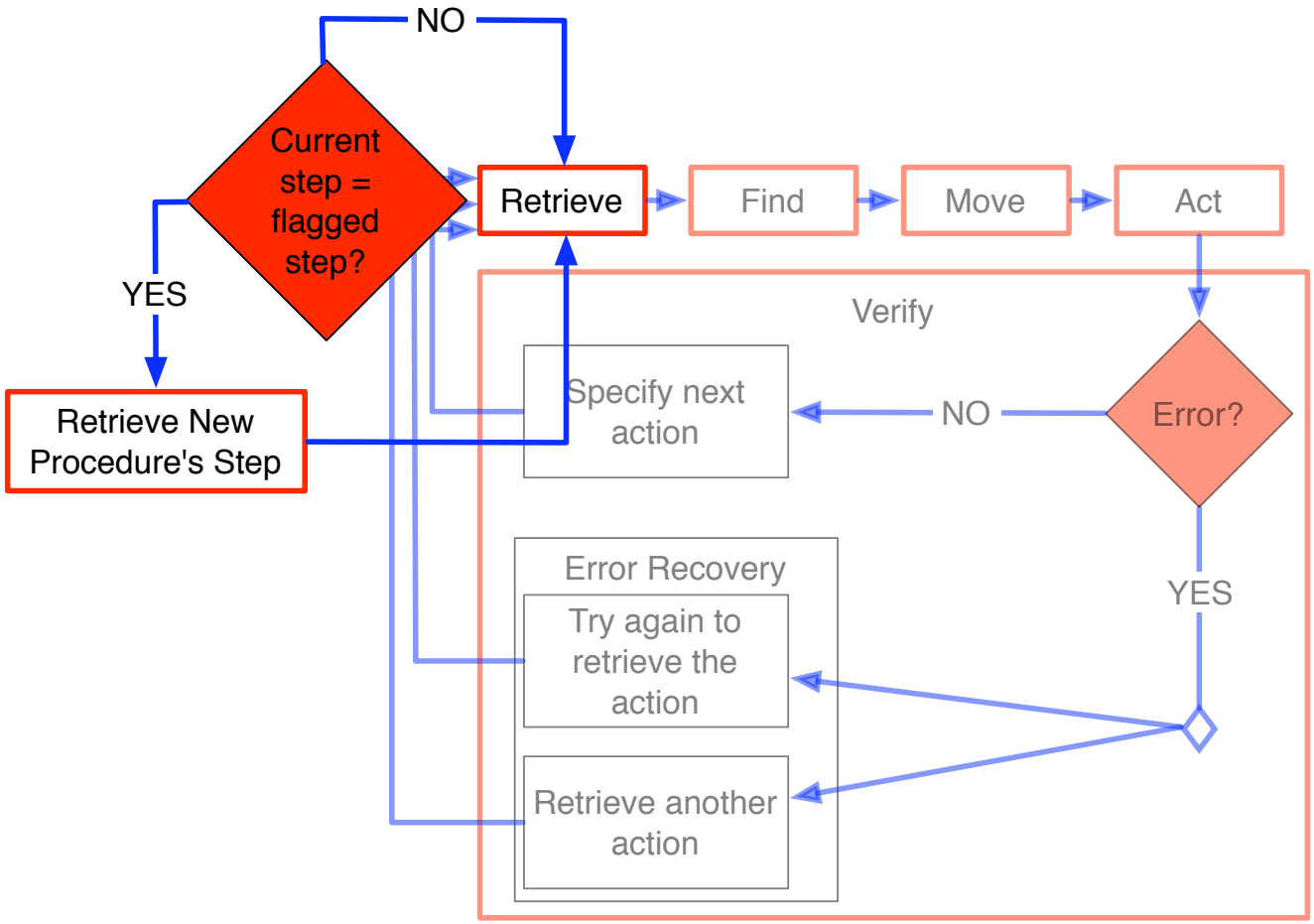
The Model

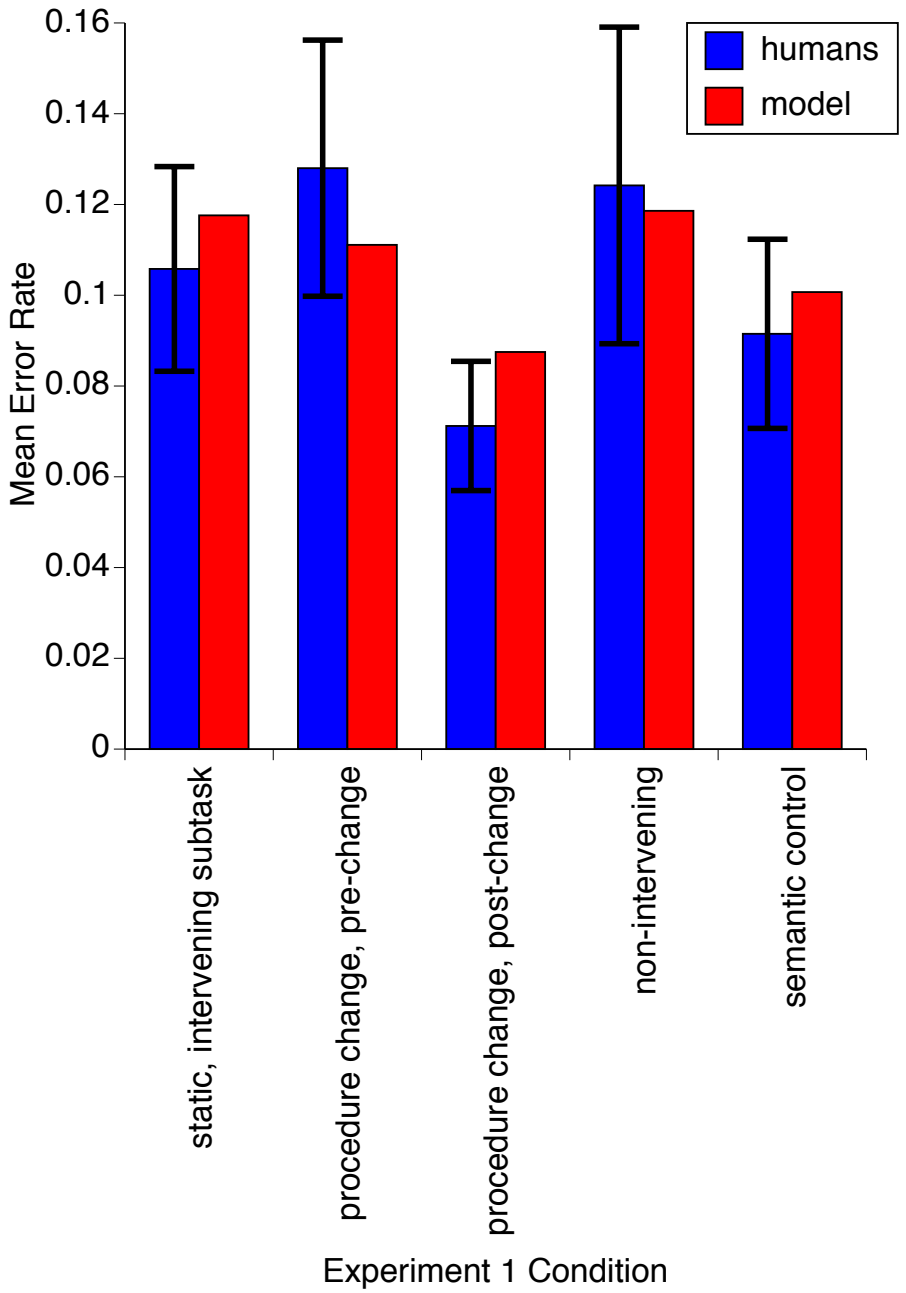
- Model Goal: Simulate error rates across conditions and trial types
  - 4 conditions
  - 14 trial types total
  - not just error generation, but also recovery
- Highest human SEM error rate = 0.0415
  - model should do no worse across the board

Basic Model Functioning



Procedure Change

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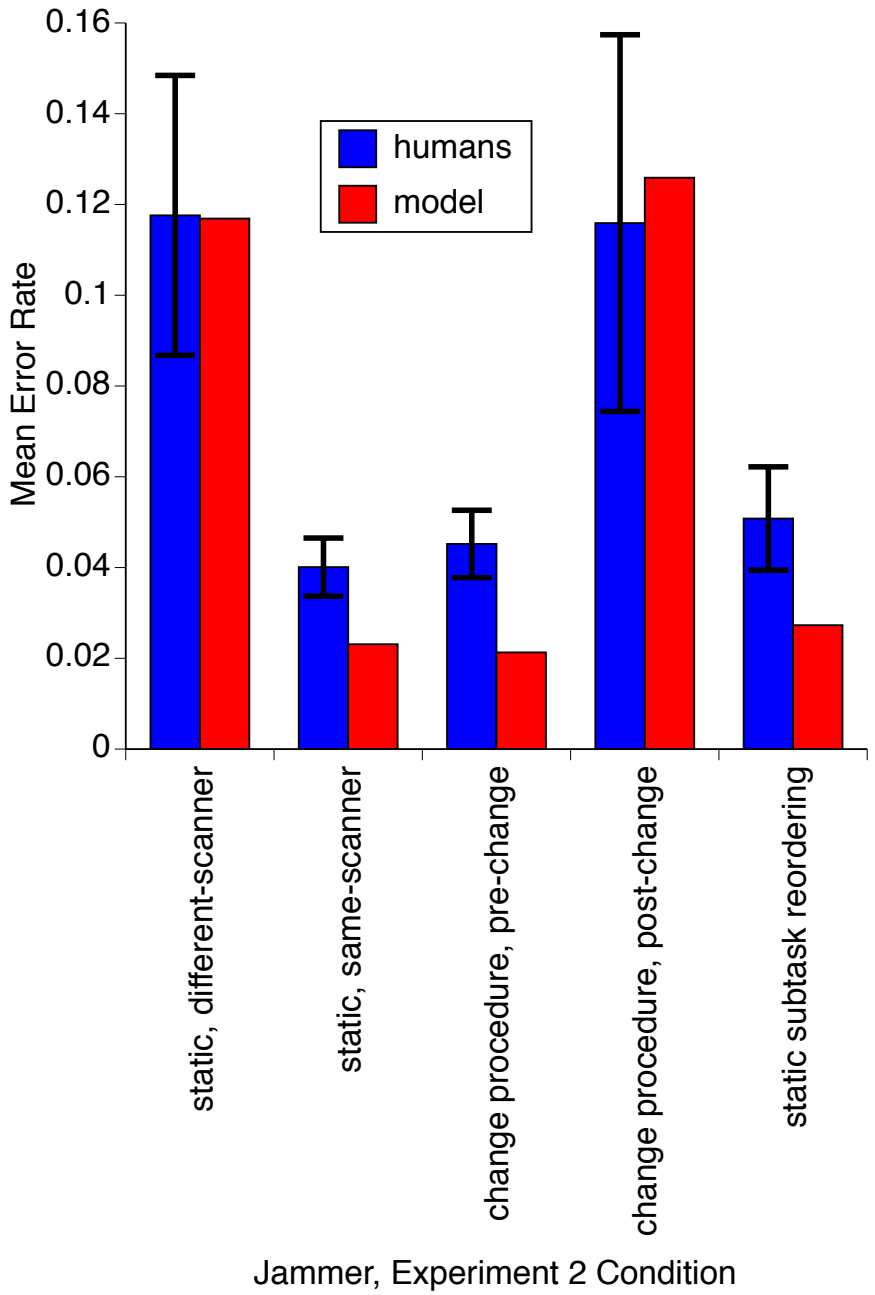
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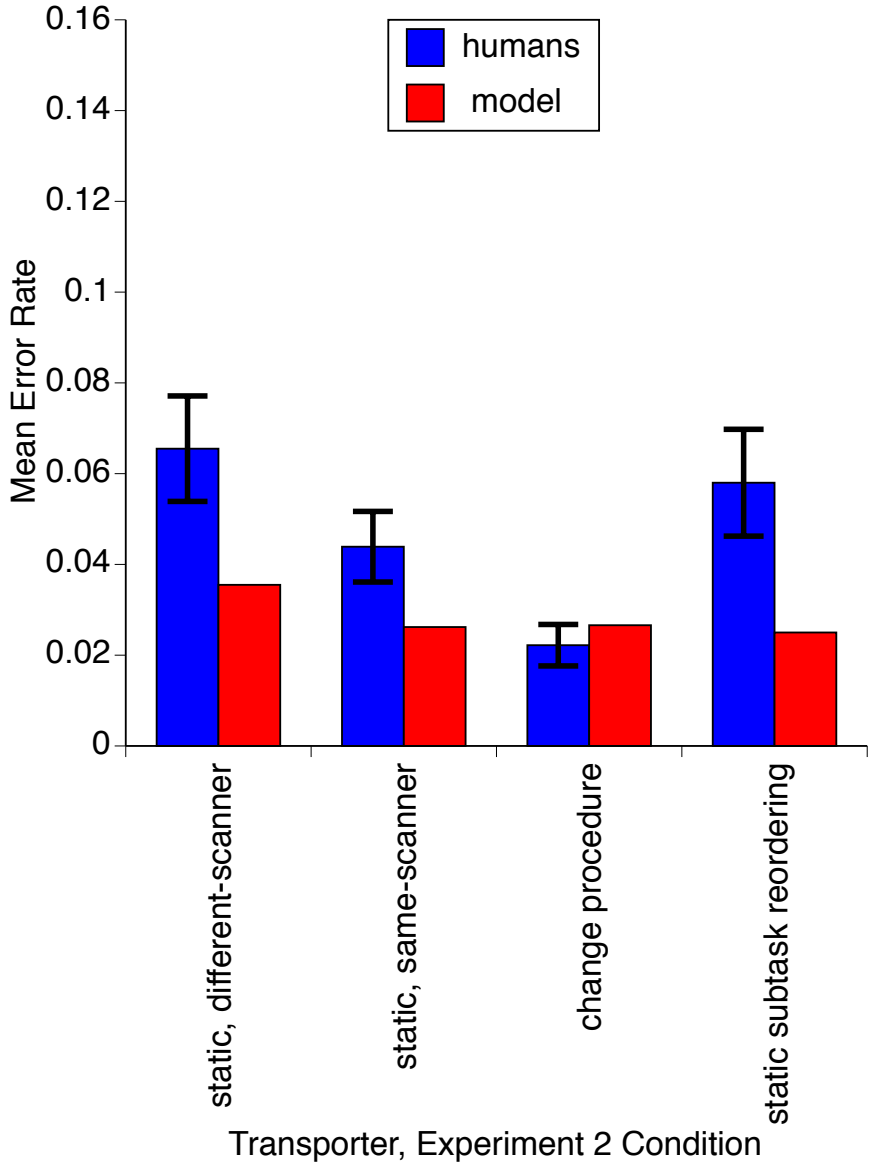
Jammer, Experiment 2 Condition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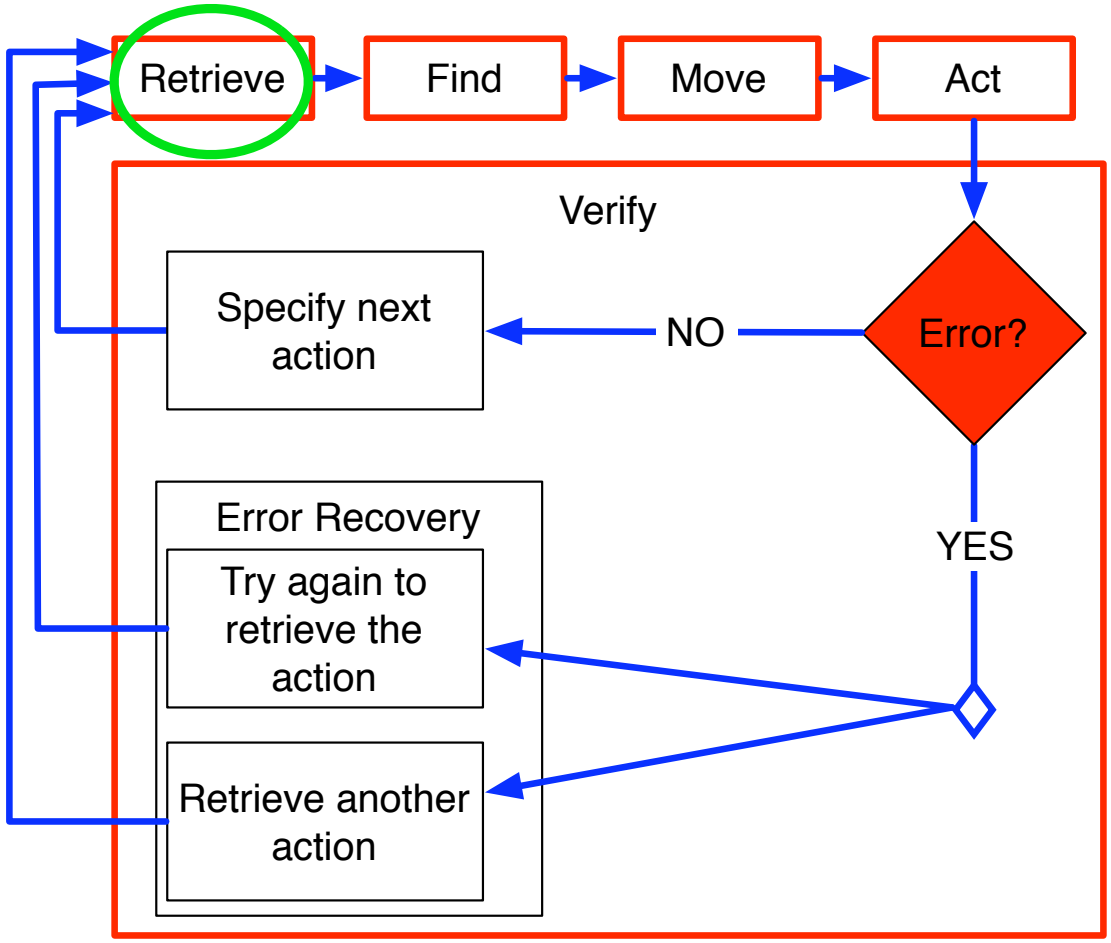
Mean Error Rate
static, different-scanner
static, same-scanner
change procedure
static subtask reordering
Transporter, Experiment 2 Condition

Model Discussion

- Discrete, hierarchical goals
  - governed basic behavior
  - enabled extensible behavior

Basic Model Functioning



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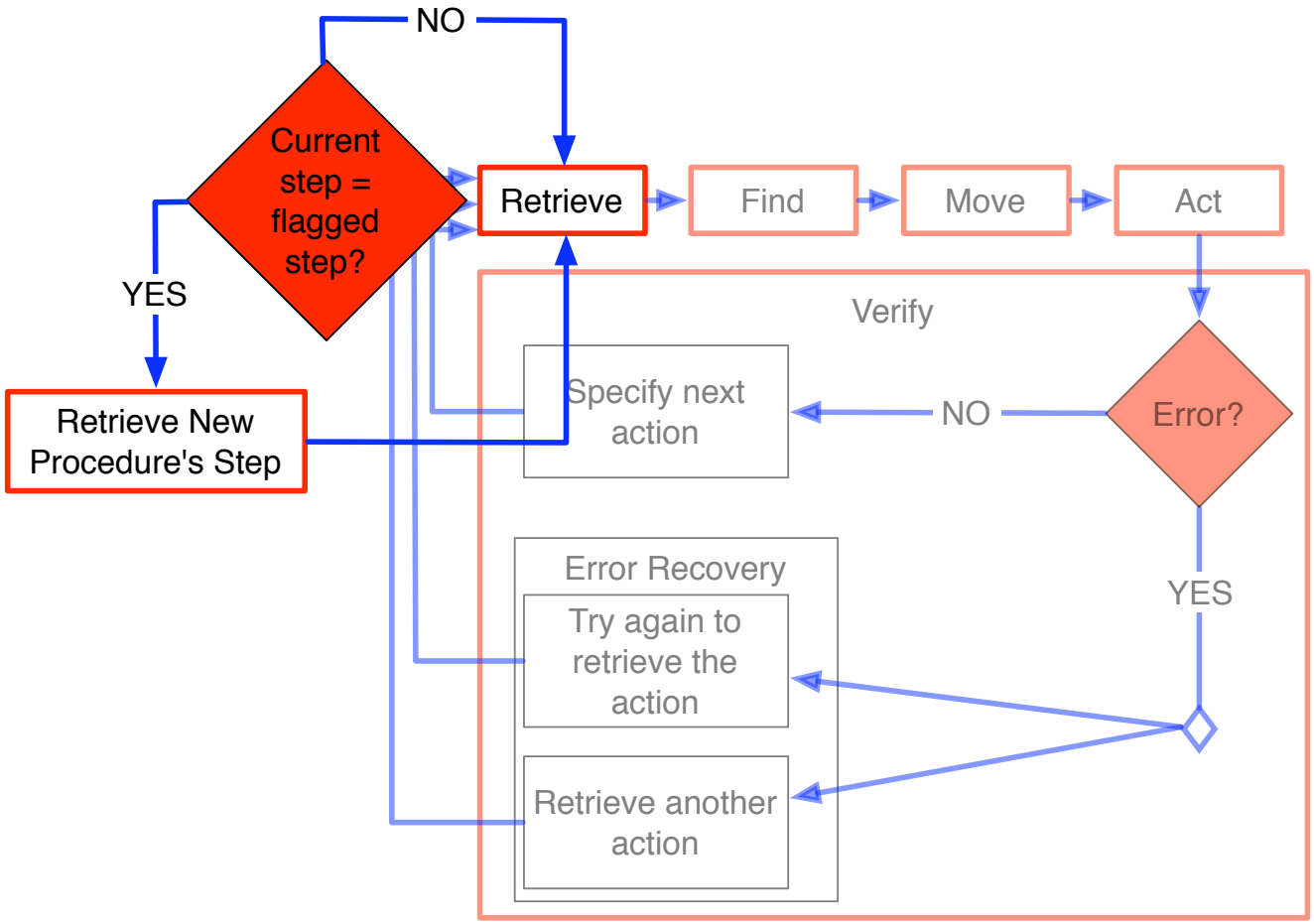

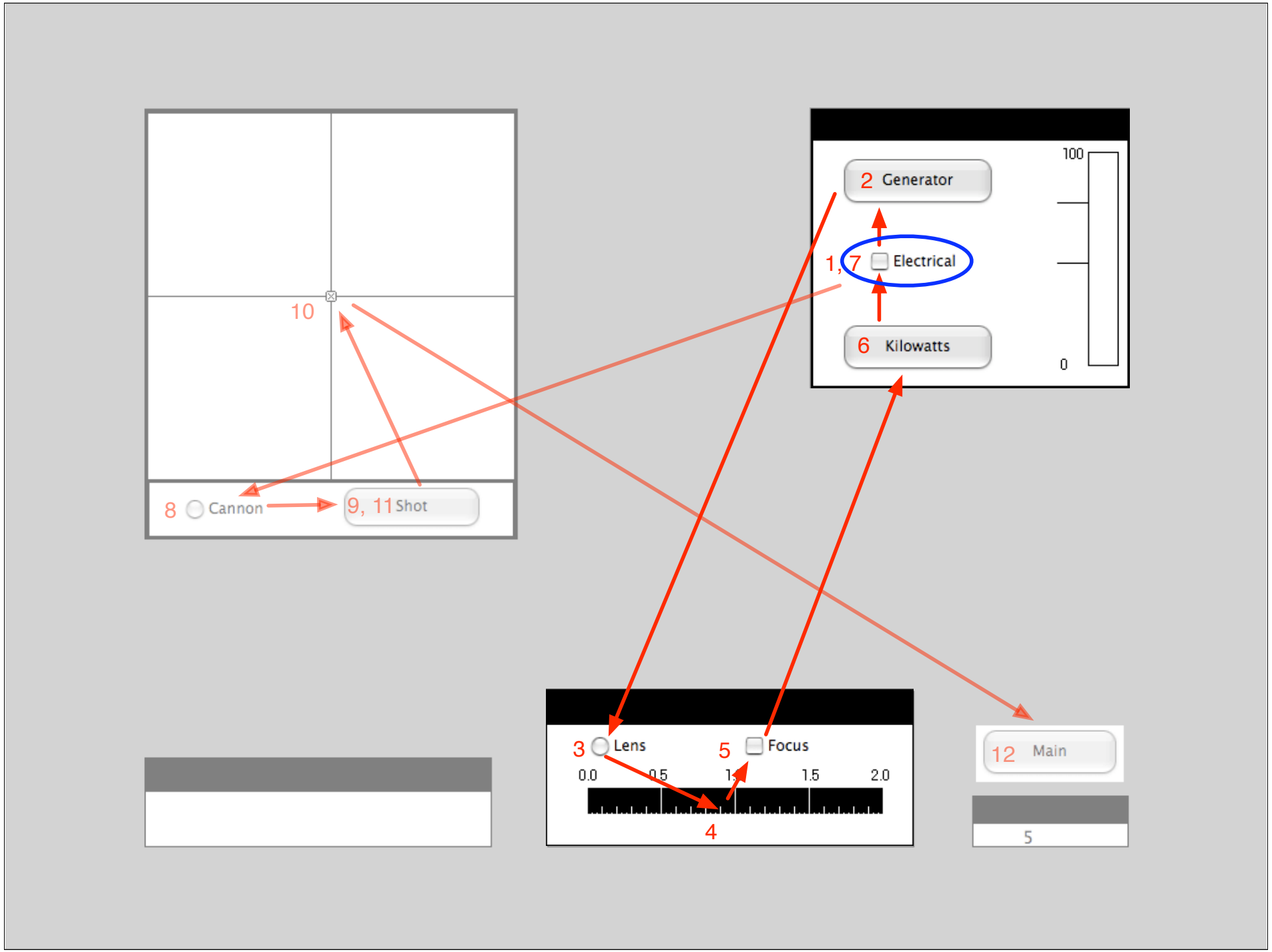
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Model Discussion

- No quantitative, multi-condition error models in literature
- Same model mechanisms across
  - 4 between-subjects conditions
  - 14 trial types

Future Work

- Extend model
  - Step-level error
  - Step completion time
- Model training, too

General Discussion

- Hierarchical, discrete goal representation matters
  - …for changing circumstances
  - …for error recovery
  - …like CSM
- Botvinick & Plaut's connectionist model too narrow
  - No postcompletion errors
  - No error recovery
  - No adaptation of old procedures to new circumstances

Acknowledgments

- Mike
- Carissa Chang & Adam Purtee
- Rick Cooper & Jay McClelland
- Kristen

Thank you!

- Questions?