Modeling Response Competition using Task-Specific and Task-Invariant Executive Processes

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Abstract

The exclude recognition task is often used to explore the interaction between familiarity and recollective processes in recognition memory. Rejecting familiar but excluded items is slower and less accurate than rejecting unfamiliar new items. Typically, this result is modeled as an interaction or conflict between familiarity-based and recollective memory processes. The current work recasts the exclude recognition task as a response-competition task, rather than a memory task per se, and models the data as an interaction between executive-control processes, memory processes, and peripheral motor processes. A general framework is developed where interaction between task-specific and task-invariant executive-processes interact and constrain one another to produce response competition data. This approach is supported by quantitative models specified within the EPIC computational architecture.

Exclude Recognition

- Exclude Recognition Task (ERT)
  - Two lists of words/phrases studied serially
  - With or without a delay between lists
  - Serial Old/New judgment task
  - Subjects asked to respond “Old” to items from other list, but “New” to new filler-items and items from other list.
  - Responses to “excluded” list tend to be slower and less accurate than filler-items.

Traditional Models of Recognition

- **Single Process Models**[1] suggest that stimulus is matched against items in memory. If *global familiarity* of a candidate is above threshold, an "Old" response is generated, otherwise "New" is produced. Similar *compound-cue* models[2] combine the stimulus and the test context into a single cue that refines the search by taking both familiarity and context into account.

- **Dual Process Models**[3] further propose that stimuli are initially evaluated using familiarity, but intermediate levels of familiarity evoke a secondary process that explicitly searches memory for the cue.

Limitations of Traditional Models

• **Single Process Models** have trouble accounting for recall-like features of recognition, e.g., organizational effects, test and lag effects, repetition effects, and list-length effects. Global-familiarity models predict that ERT data would show an uncharacteristic 100% false alarm rate for the excluded list. Compound-cue varieties, which can limit global candidates by context (e.g., list identity), predict an equally unlikely 0% false alarm rate for excluded items.

• **Dual Process Models** successfully account for search-like effects in recognition, but like single-process models, over- or under-predict the false-alarm rate for excluded items in the ERT.

Jacoby's Dual-Process Model

- Jacoby's model of the ERT[4,5] explains why subjects sometimes, but not always, respond "Old" to items on the excluded list.

  - Responses are a combination of the p(**R**ecall) and p(**F**amiliarity) exceeding a criterion.

  - Responses are a combination of familiarity and recollective processes, but incorrect "Old" responses to excluded items are driven by familiarity when recollection <u>fails</u>.

  - p(correct "Old" response on **I**nclude task) =

$$P(R)+P(F)\times(1-P(R))$$

  - p(wrong "Old" response on **E**xclude task) = $P(F)\times(1-P(R))$

Limitations of Jacoby's Model

- Jacoby's model successfully highlights relative influences of familiarity and recollection, and predicts accuracy data, but:
  - Assumption that responses are driven by failed recollection rather than misrecollection not supported by data[6].
  - No obvious account of RT data (although see McElree et al. 1999[7]), especially when response deadlines are used.
  - Assumption that item's familiarity remains constant across retrieval contexts not supported by data[8].
  - Does not describe how memory interacts with other cognitive systems.

Goals of Current Research

- Develop process model that accounts for ERT data including:
  - RT & Accuracy
  - Practice effects
  - Influence of strategic manipulation
- Describe interaction between memory, control, & motor system[9].
  - Incorporate response-conflict monitor attributed to brain's anterior cingulate cortex[10].
  - Incorporate constraints of motor system[11].
  - Incorporate Point of No Return in motor system[12].

Parallel Task-Set Model

- Stimulus evokes two complete and independent task-sets:
    - Slower context task-set recollects (or *mis*recollects) item study-context and produces context-based response
    - Faster familiarity task-set evaluates stimulus familiarity and responds without regard to context task-set.
- Motor system can only prepare one response program at a time, multiple response requests causes “Jam.”
- Response-conflict monitor avoids jamming motor processor by favoring subsequent response preparation request when earlier preparation request is already underway.

Parallel Task-Set Model

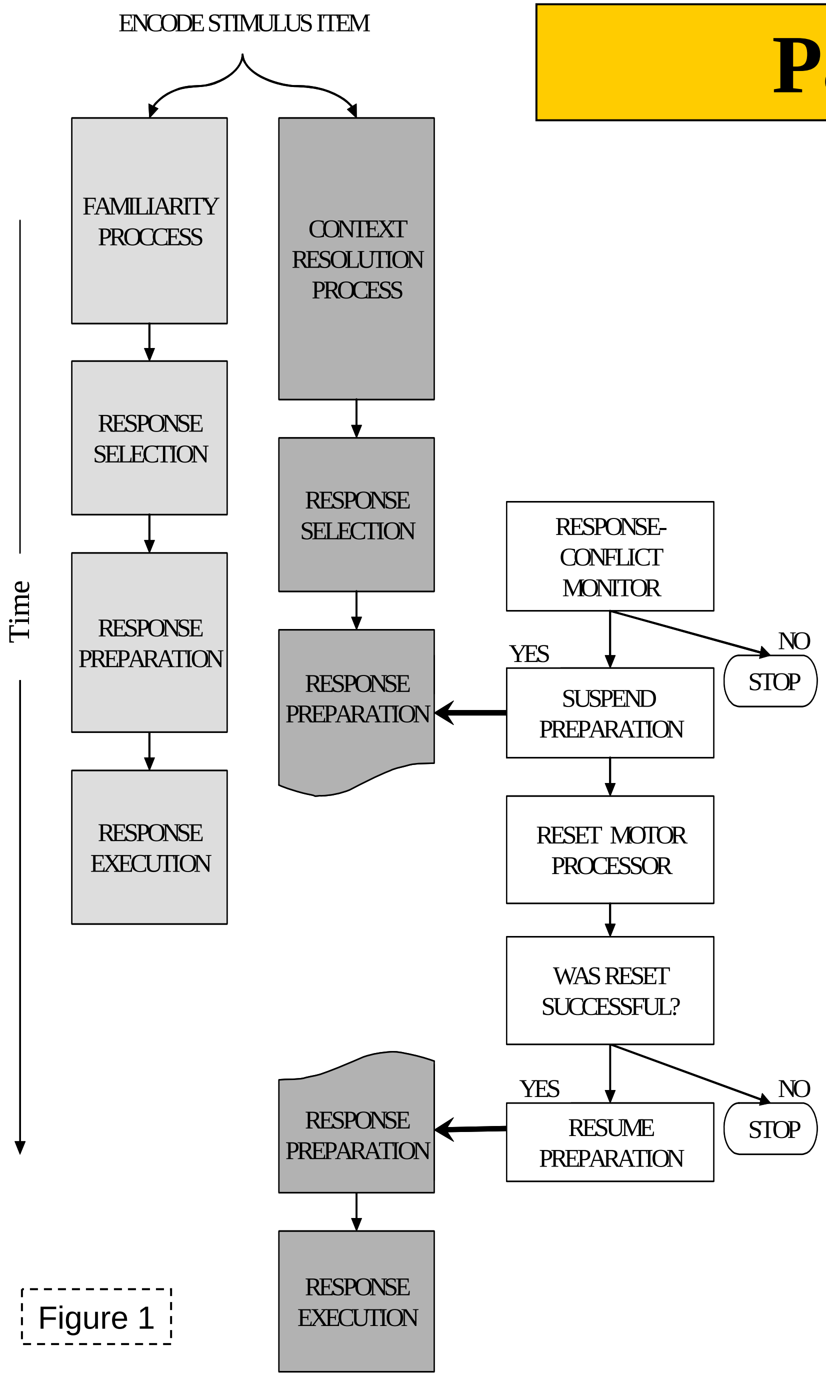


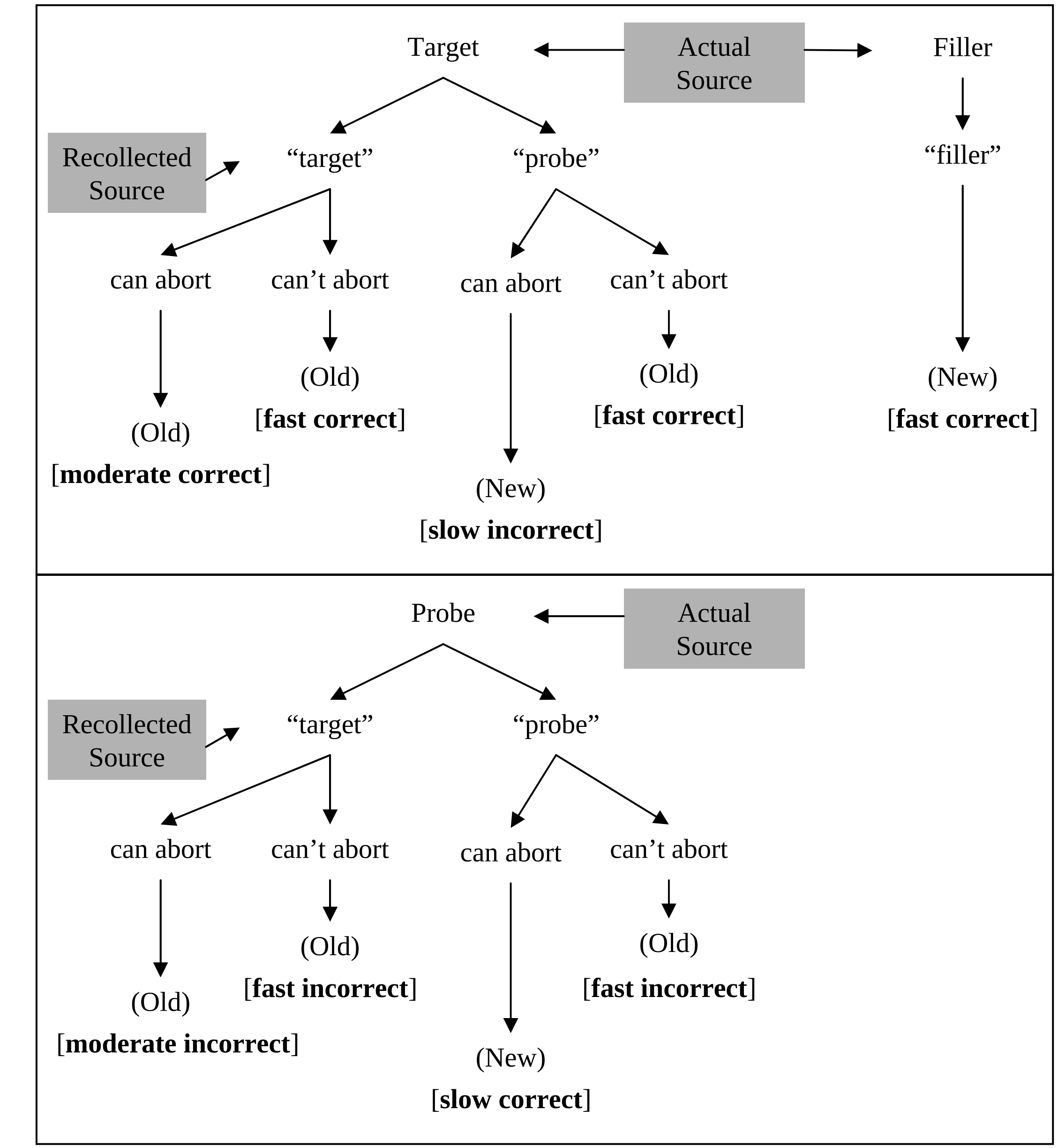
Figure 1

- Familiarity process tends to request preparation (prep) first. Later context prep arrives and triggers response-conflict monitor.
- Once triggered, monitor suspends subsequent prep and attempts to abort current one.
- If abort attempt arrives earlier enough, slower context response is made, otherwise original (faster) familiarity response is made.

Effects of Variable Memory Process Duration

- If context-resolution process is slower than familiarity process:
  - If abort is successful, then correct ("New") exclude response results, but is slowed by suspend/abort/resume. This accounts for increased RT on correct exclude trials.
  - However, if abort is unsuccessful, then fast error is made accounting for increased error rate on exclude trials.
- The context-resolution process may complete faster than the familiarity process causing the conflict monitor to facilitate a slow error on some exclude trials.
- The conflict monitor may also facilitate an error if the context-resolution process misrecollects stimulus source.

Effects of Variable Memory Process Duration



- Fig 2 shows how recollected source interacts with point-of-no-return (abort success) to produce various RT and accuracy outcomes.
- An "Old" response may be facilitated if aborted response is also "Old" because motor preparation persists (e.g., "**moderate correct**" instead of "**slow correct**" in Fig 2).

Experiment 1

- Fig 3 shows a schematic of Exp 1[13]. Subjects study 2 lists of phrases separated by a 10 min distractor task.

- Subjects are then presented with a series of phrases and given 1 second to respond

    - "Old" only to items from list 2 (**Target items**; 1/6 trials)

    - "New" to items from list 1 (**Probe items**; 1/6 trials)

    - "New" to new items (**Filler items**; 2/3 trials).

- During "familiar-probe block" Probes are taken from excluded Probe list (exclude-recognition block). During "unfamiliar-probe block", Probes are essentially Fillers.

Experiment 1 Method

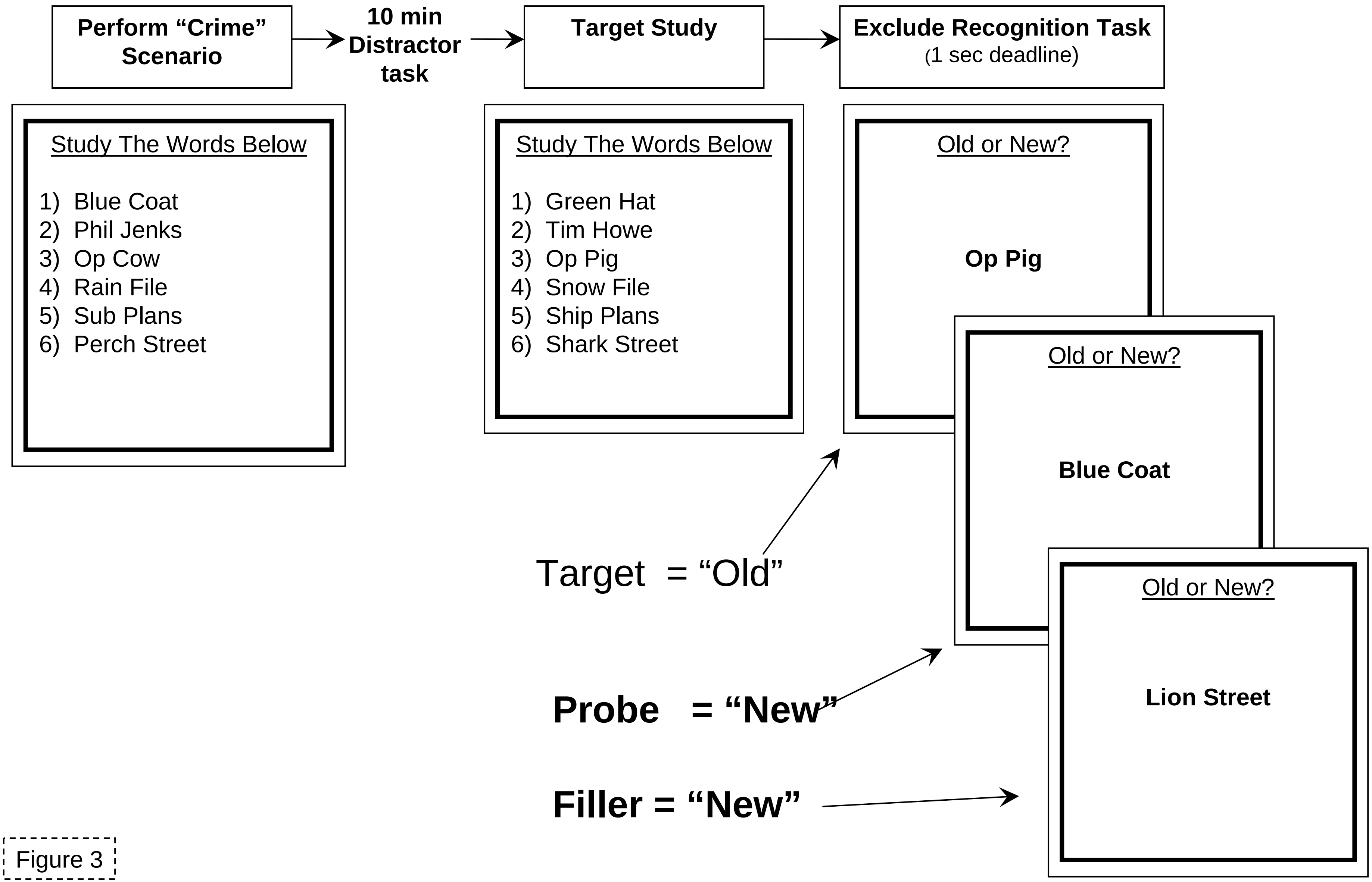


Figure 3

Experiment 1 Results

Figure 4

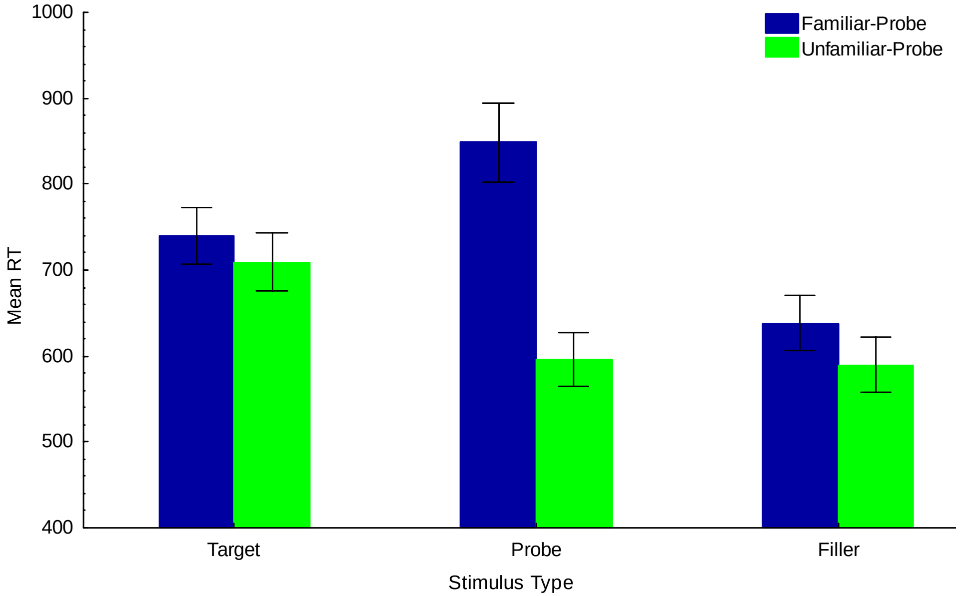
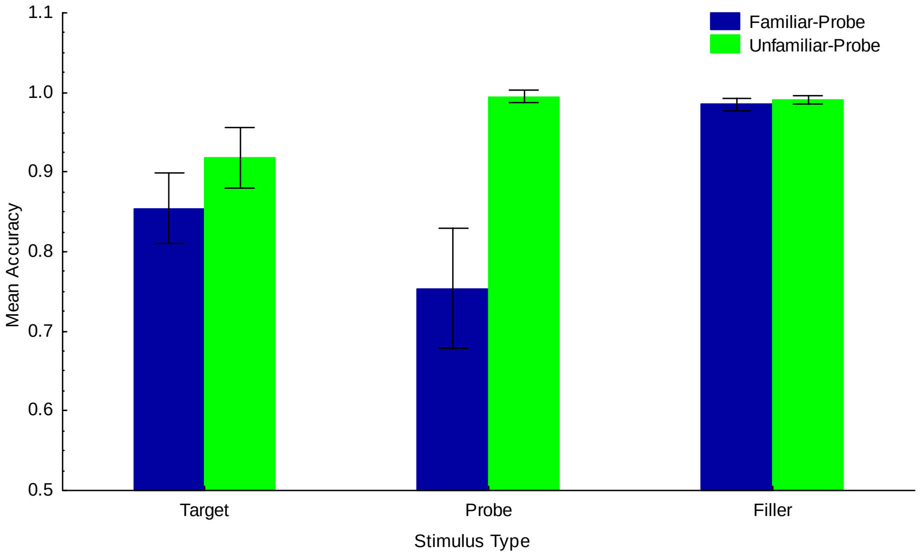


Figure 5



The graphs plot mean RT (left) and accuracy (right) as a function of stimulus type. When Probes are familiar (i.e., from excluded list), responses to Probes are slower and less accurate than to Fillers. When Probes are unfamiliar (i.e., similar to new fillers), responses to Probes and Fillers are indistinguishable.

Applying the PTS model to Experiment 1 Results

- Specify model within EPIC computational architecture
  - Familiarity and context task-sets are complete & independent rule sets, each capable of responding to all stimuli.
  - Response-conflict monitor implemented as task-independent set of executive processes.
  - EPIC's motor system already "jams" if new preparation arrives while previous preparation is underway.
  - Three parameters are used to fit model: 1) familiarity process duration, 2) context-resolution process duration, and 3) context-resolution misrecollection rate.

RT Modeling Results

Figure 6

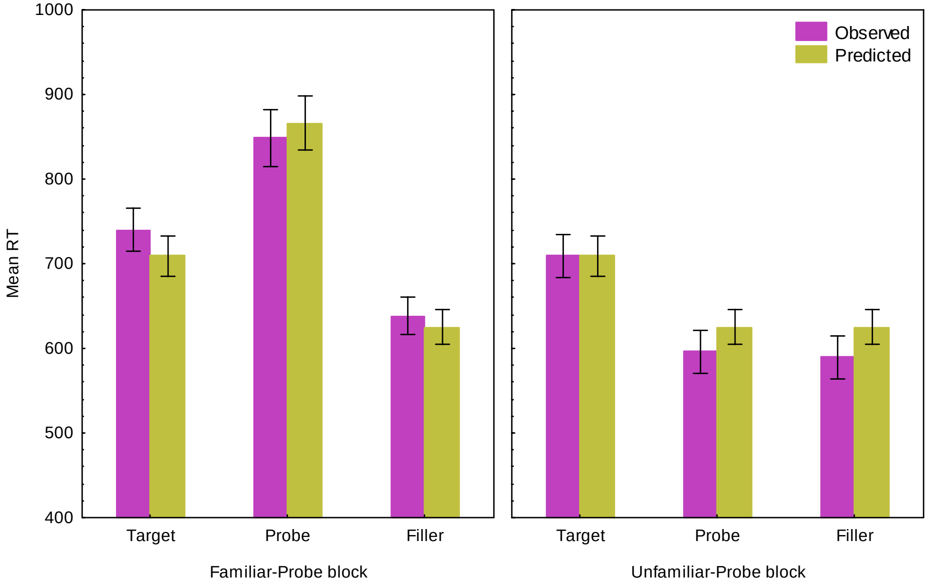
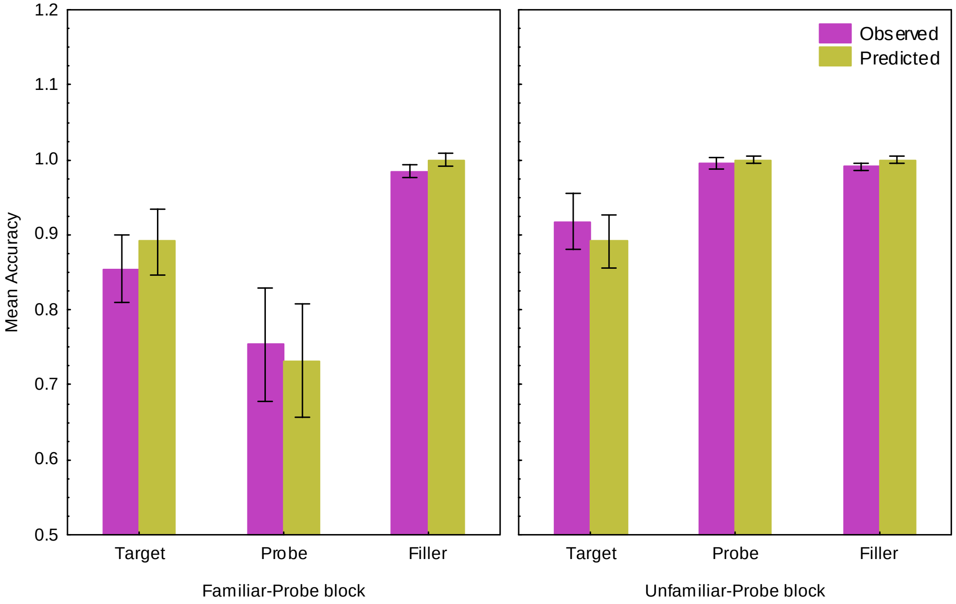


Figure 7



- By implementing the PTS model using the EPIC architecture, the RT (Fig 6) and accuracy (Fig 7) data can be successfully simulated for standard recognition as well as exclude recognition.

Conclusion from Model

• Parallel Task-Set (PTS) model is capable of modeling ERT data as interaction between memory processes, task-invariant response monitoring processes, and limited motor processes.

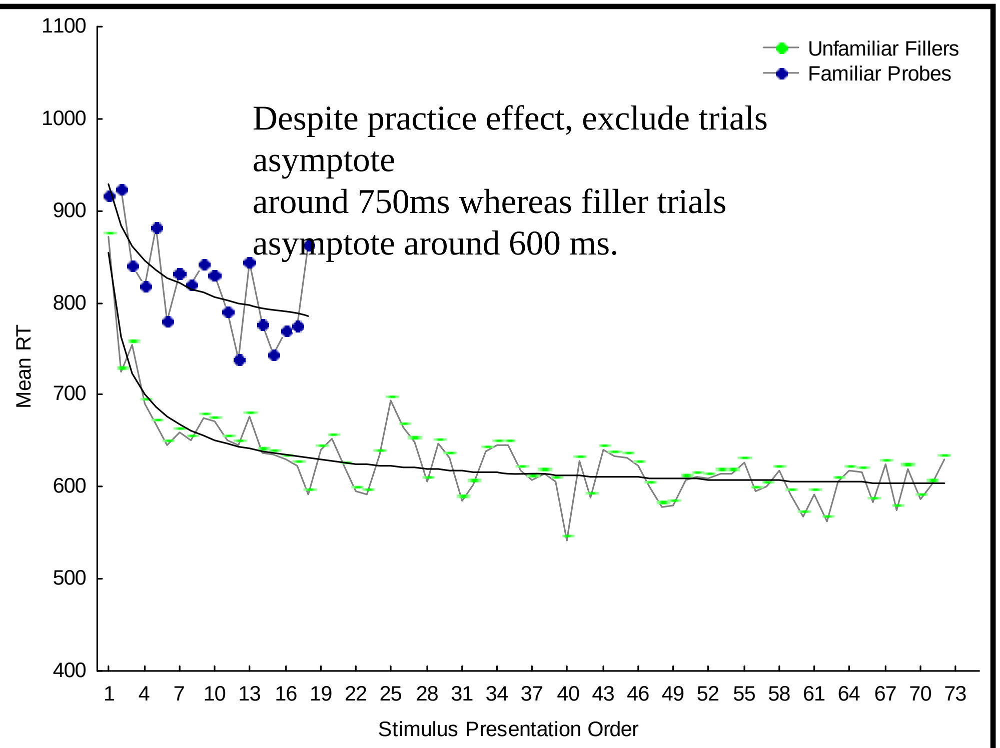
• Unlike Jacoby's account, source confusions play important role in RT and accuracy effects.

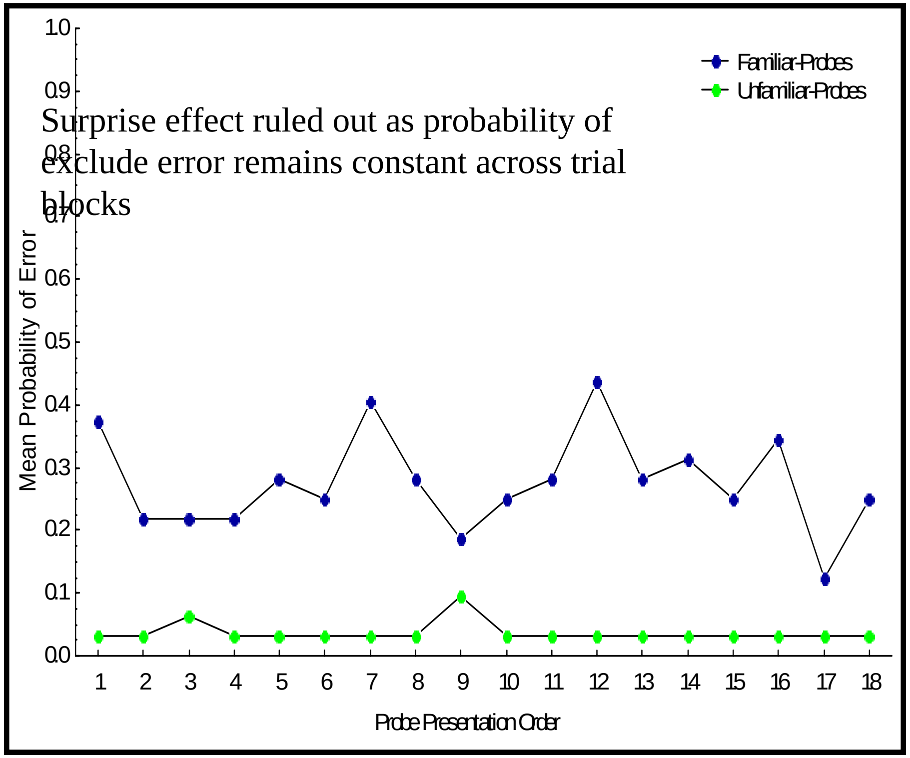
• Relative variability of memory processes interact with Point of No Return, and source confusions, to produce RT and accuracy effects.

• Tasks typically modeled as interaction between memory processes alone may be interactions between multiple systems.

Predictions of the PTS model

• The model assumes that the unintentional familiarity task-set is evoked by the stimulus despite the subject’s strategy or motivation. Thus, the competition between the task sets is unlikely to attenuate with practice:





Predictions of the PTS model

- Even with a more liberal response deadline, correct exclude trials require a quick response, otherwise probability of aborting fast familiarity response (not affected by response deadline) decreases. Thus, a liberal deadline should not attenuate effect for exclude trials.

- Model assumes that initial familiarity-based response may be replaced by subsequent context-based response on exclude trials. Thus, EEG or EMG should show initial preparation of one response then switch to alternative response.

Applying PTS model to other tasks

- May be possible to apply PTS model to more traditional response competition tasks:

    - The Stroop[14] task could be modeled by replacing the familiarity process with a word-reading (WR) process and replacing the context-resolution process with a color-naming (CN) process. A slight disparity between WR and CN completion times would yield a moderate RT effect and only a slight accuracy effect on conflict trials similar to Stroop data.

    - Without appealing to attention processes, this approach may fall short of fully accounting for Stroop, but may suggest that motor and control processes are more important than thought.

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