A race model of perceptual forced-choice reaction time

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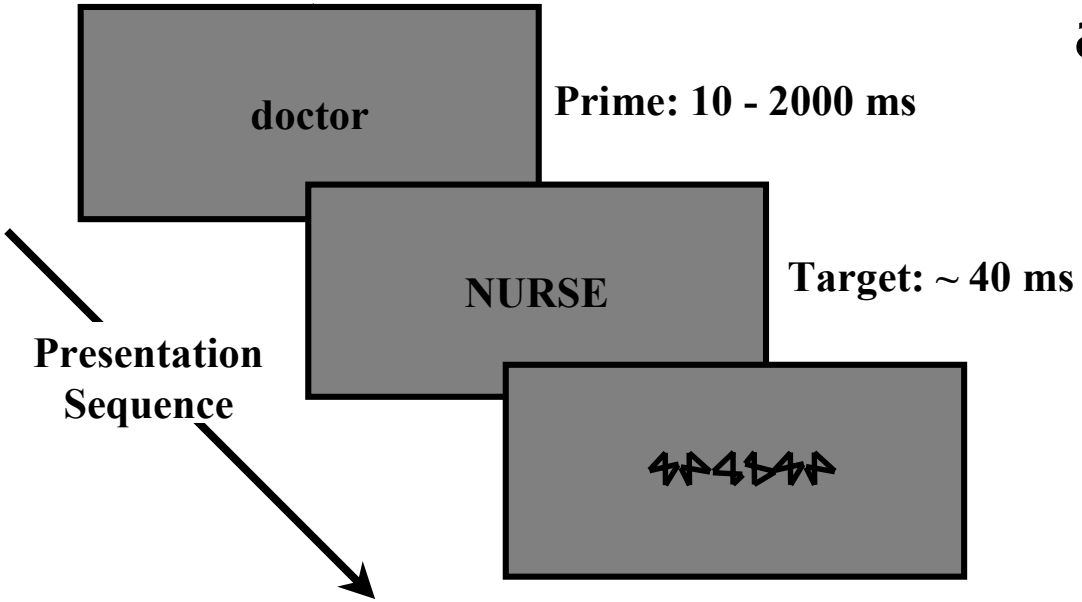
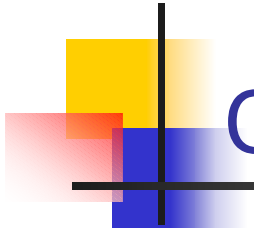
Perceptual identification in priming studies

- Short-term priming: a "prime" word followed by a "target" word.



- In a 2AFC lexical decision, nurse is recognized as a word more easily (Meyer & Schvaneveldt, 1971).



Questions

- In perceiving sequences, how does previous items affect later items?

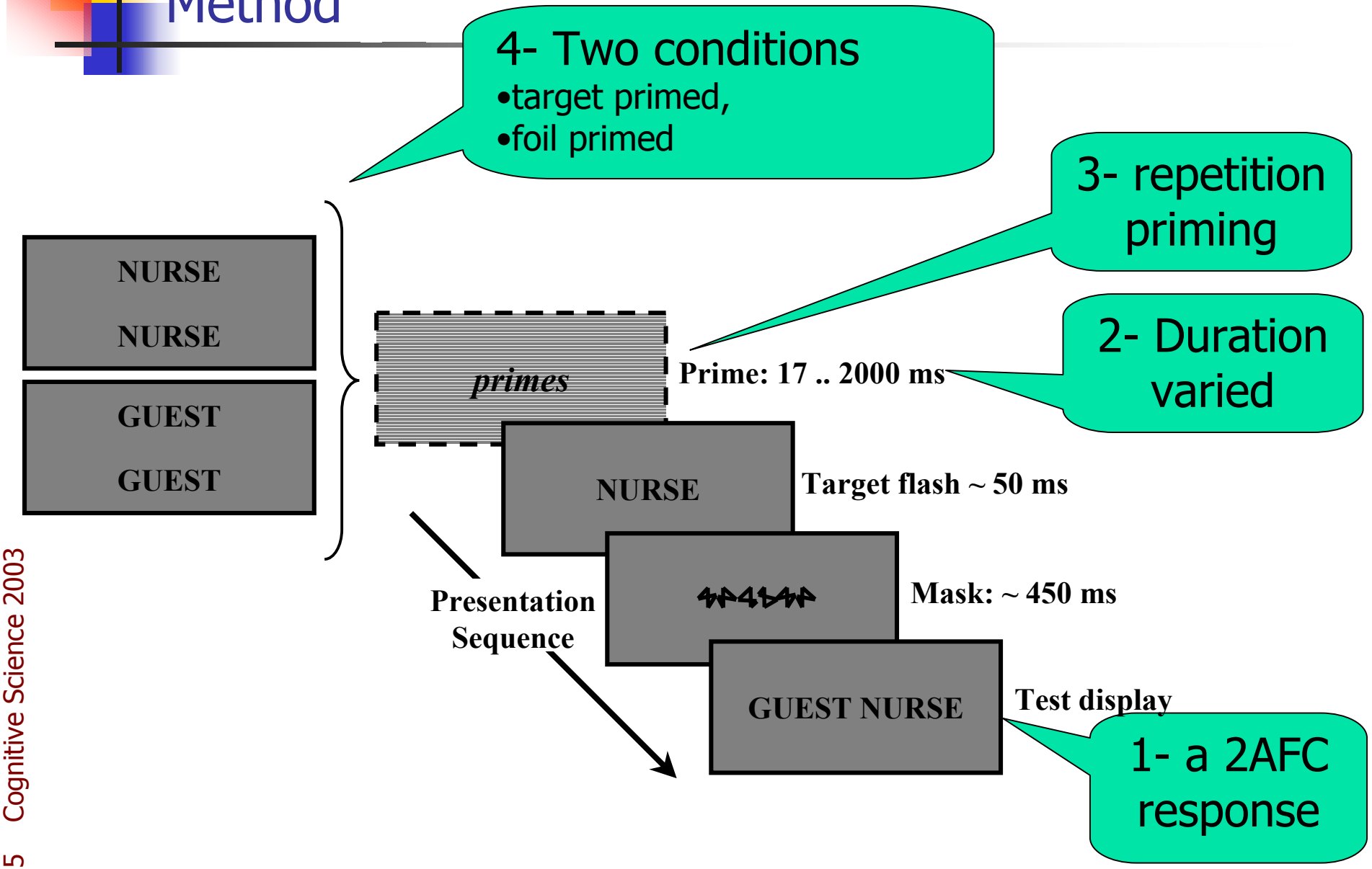
- Phenomenon:
  - Choice data:
    - Choice preferences.
    - Is it discounting –or– saturation?
  - Response times (RT):
    - What is the time course of a correct response?
- Modeling:
  - A race model of RT decisions and of percent correct

Overview

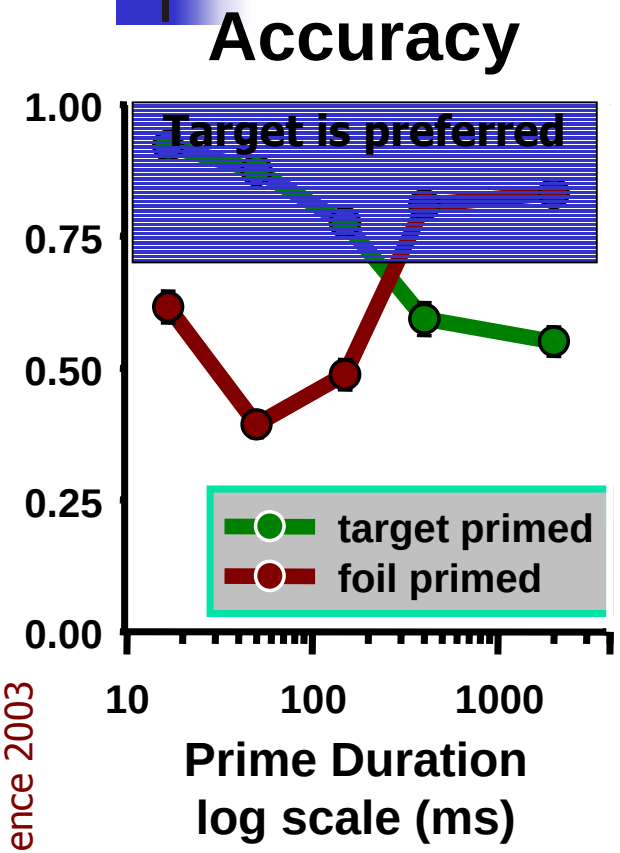
- A- Experiment 1
  - Choice preferences
  - Response times
- B- Race model of RTs
- C- One test of the model

A- Experiment 1

A- Experiment 1
Method



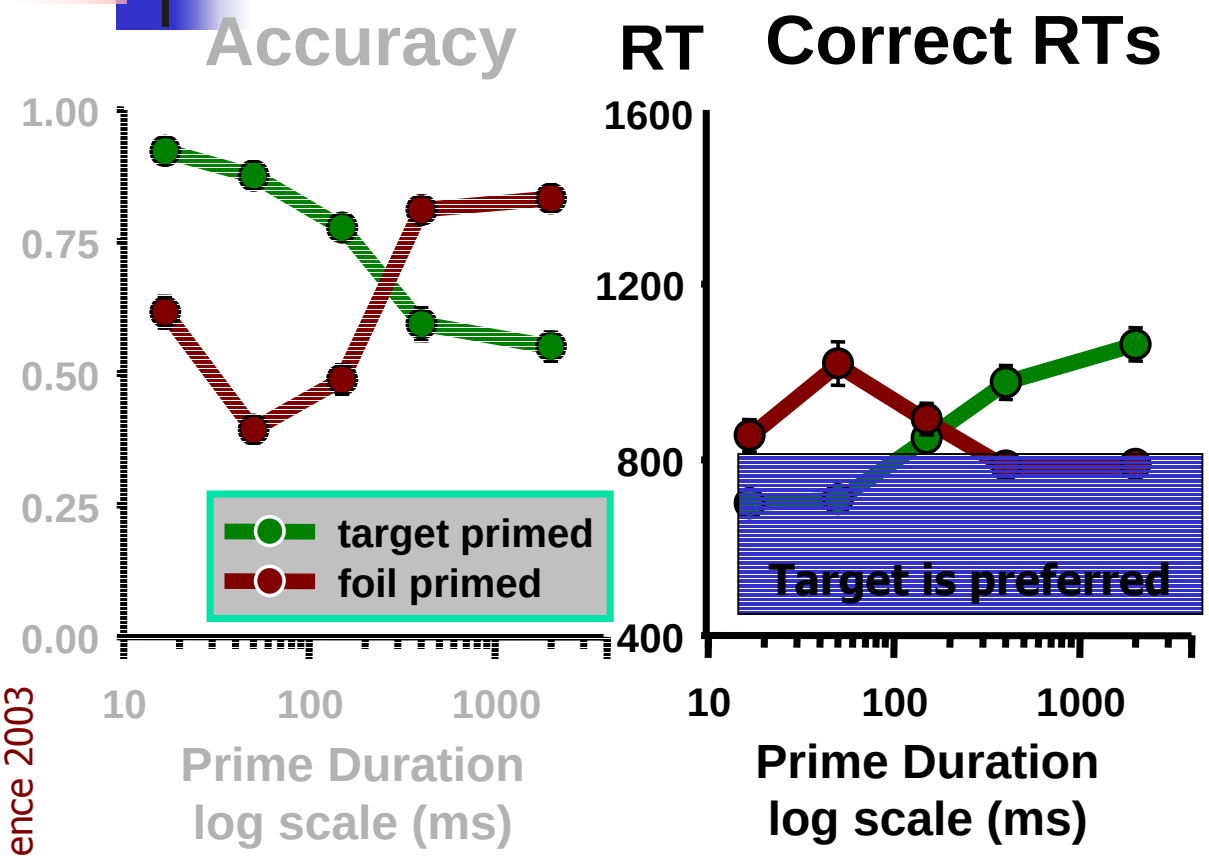
A- Experiment 1
Results a) accuracy



- Short prime durations (below 300 ms):
  - A preference to choose the repeated word
- Long prime durations (above 300 ms):
  - The preference reversed
    (the primed alternative is "mistrusted").

A- Experiment 1

Results b) Response times for correct responses

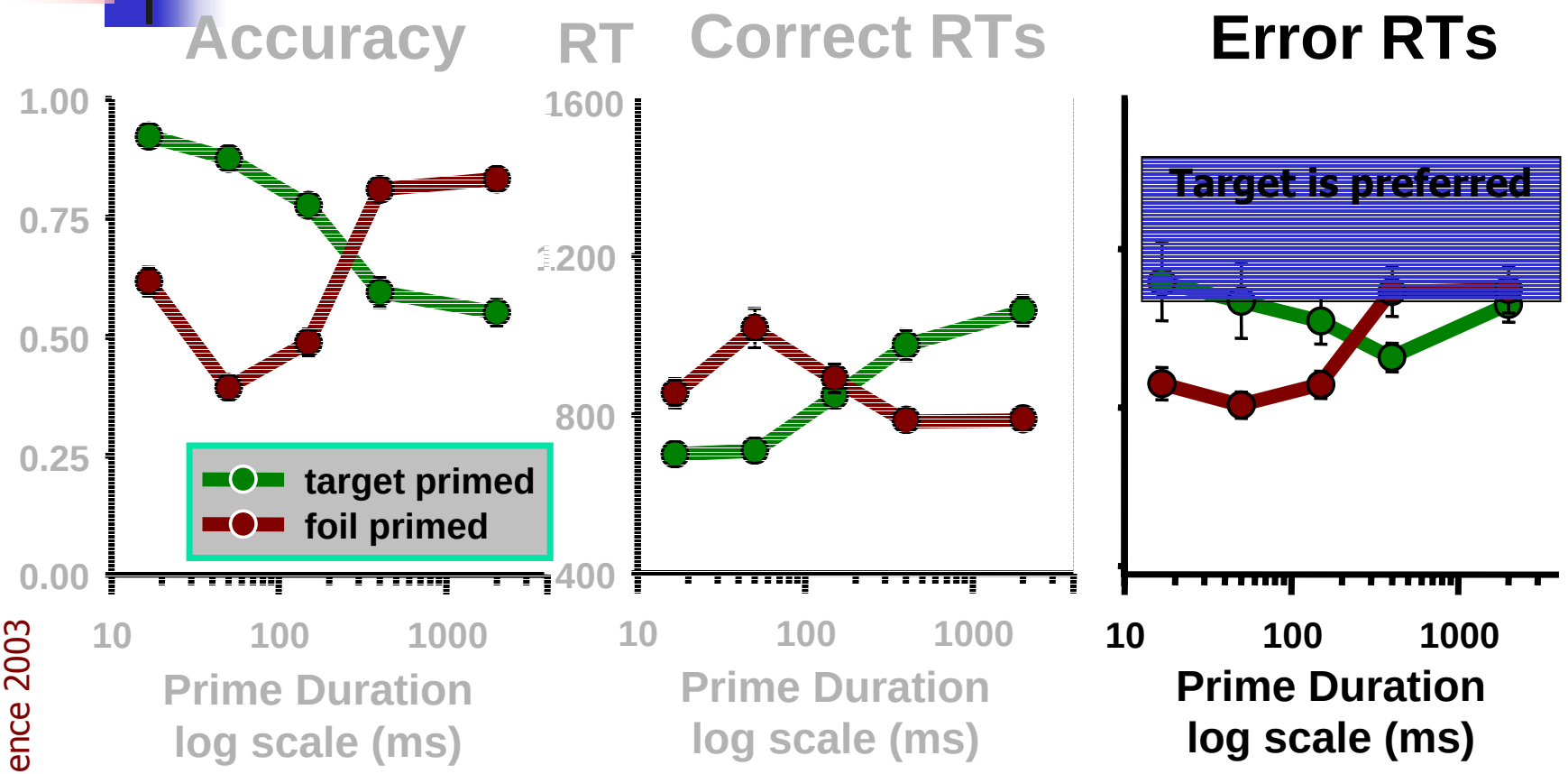


- The target is chosen rapidly when it is the preferred alternative;
- The target is chosen slowly when the foil is the preferred alternative.

  Faster ➔ more accurate

A- Experiment 1

Results c) Response times for error responses



- The foil is chosen rapidly when it is preferred;
- The foil is chosen slowly when the target is preferred.
  Faster ➔ less accurate

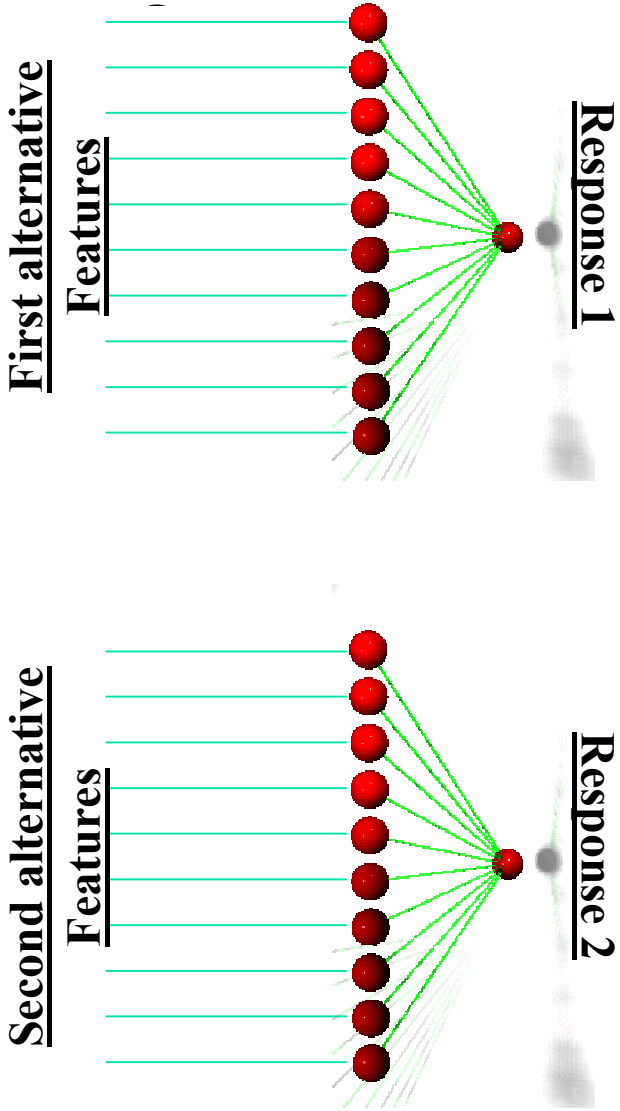
A- Experiment 1
Conclusion

- Choice:
  - Preference for repeated word if primed briefly. As if:
  - The participants are aware of a possible source confusion and tries to discount it (Baysian approach, ROUSE, Huber et al., 2000; inhibition and neural networks approach, nROUSE, Huber et al., 2002) –or –
  - The system is saturated and cannot devote as many processors to the primed word after a certain time.

- RTs:
  - The preferred word is chosen rapidly. As if:
  - The alternative were racing but the preferred alternative started ahead of time.

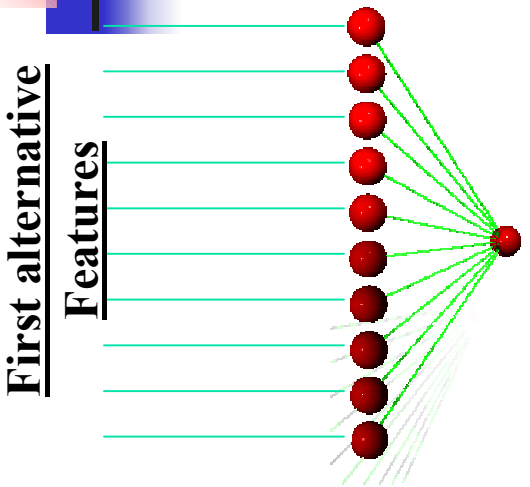
B- Race model of RTs

B- Race model of RTs
ROUSE and race model

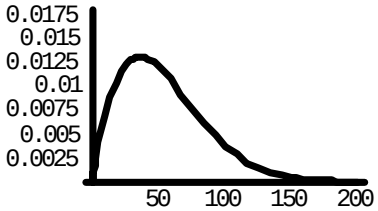


- The units on the first layers take their activation from the stimuli
- The units on the second layer accumulate evidences for either alternatives.
- The first output unit that fires triggers a response
  - Race model

B- Race model of RTs
Computations



$f_1(t) = \Pr(\mathbf{T}_1 < t)$



Assuming that the target is the first alternative:

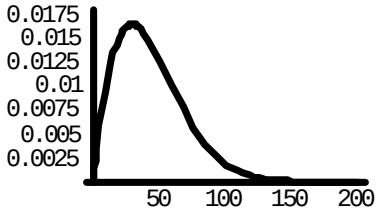
$$f_C(t) = \Pr(\mathbf{T}_1 = t \,\&\, \mathbf{T}_2 > t)$$
$$= \Pr(\mathbf{T}_1 = t \,\&\, \mathbf{T}_2 > t)$$
$$= \Pr(\mathbf{T}_1 = t)\Pr(\mathbf{T}_2 > t)$$
$$= \Pr(\mathbf{T}_1 = t)\Pr(\mathbf{T}_2 > t)$$
$$= f_1(t)\left(1 - F_2(t)\right)$$

$$P(c) = \int_{\forall x} f_C(t)dt$$
$$= \int_{\forall t} f_1(t)\left(1 - F_2(t)\right)dt$$

analytic →

← **best-fit**

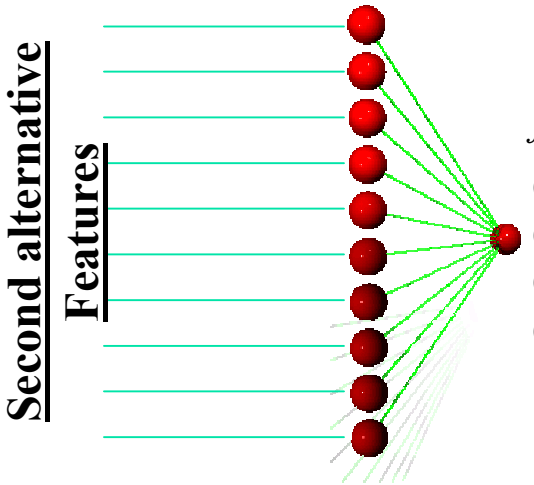
$f_C(t) = \Pr(\mathbf{T}_1 < \mathbf{T}_2)$



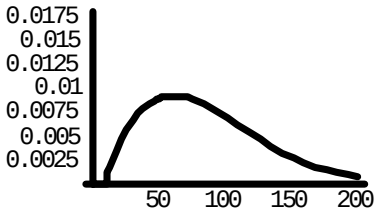
P(c) = 75%

Mean(c) = 43

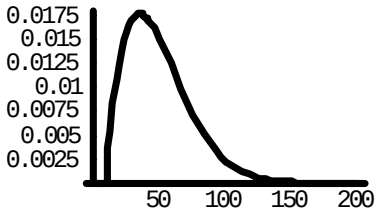
Mean(e) = 51



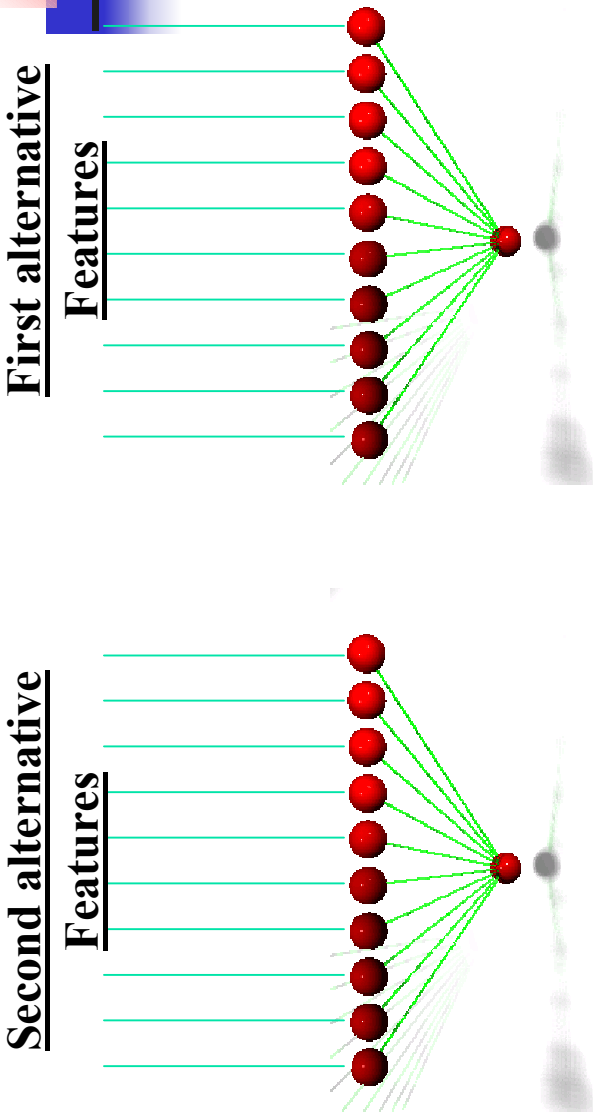
$f_2(t) = \Pr(\mathbf{T}_2 < t)$



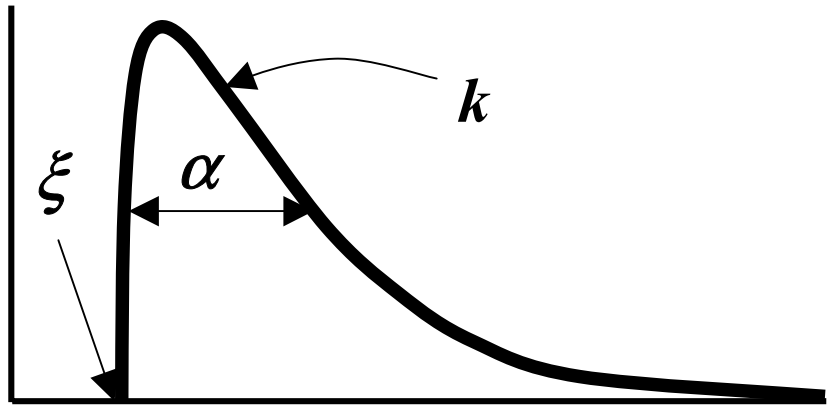
$f_E(t) = \Pr(\mathbf{T}_2 < \mathbf{T}_1)$



B- Race model of RTs
Asymptotic statistics of extremes



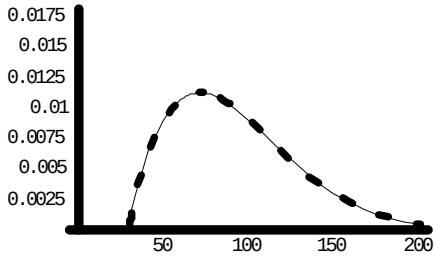
- What are the f distributions?
  - According to the Extreme Limit Theorem (Cousineau et al, JMP 2002),
  - and assuming there are many features in competition to fill each response unit,
  - the output of one unit should be a Weibull distribution $f(t) = W(t \mid \xi, \alpha, k)$:



B- Race model of RTs

What could the prime do?

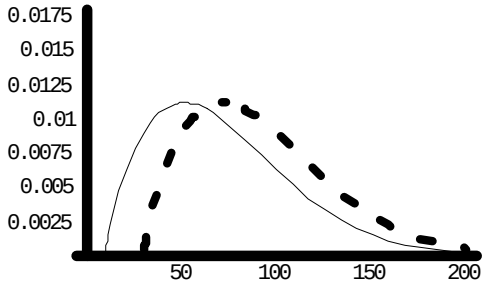
No prime condition



Both alternative have the same distribution of finishing time.

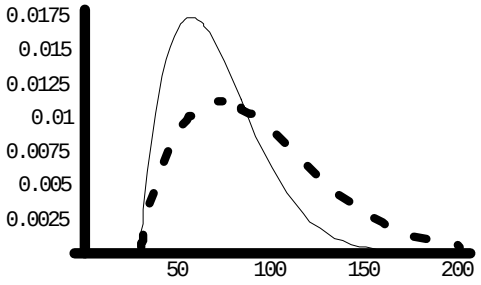
Priming alternative 1

Scenario 1



-or-

Scenario 2

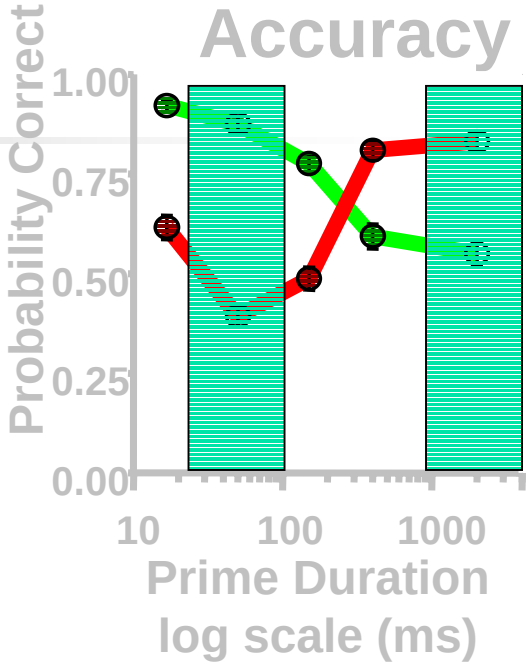


The onset –or– the scale parameter can be reduced.

The shape parameter was kept a constant for all subjects in all conditions (k = 1.3).

C- Experiment 2

C- Experiment 2
Method



1- Only 2 durations

NURSE
NURSE
GUEST
GUEST

primes

Prime 150 or 2000 ms

NURSE

Target flash ~ 50 ms

Mask: ~ 450 ms

GUEST NURSE

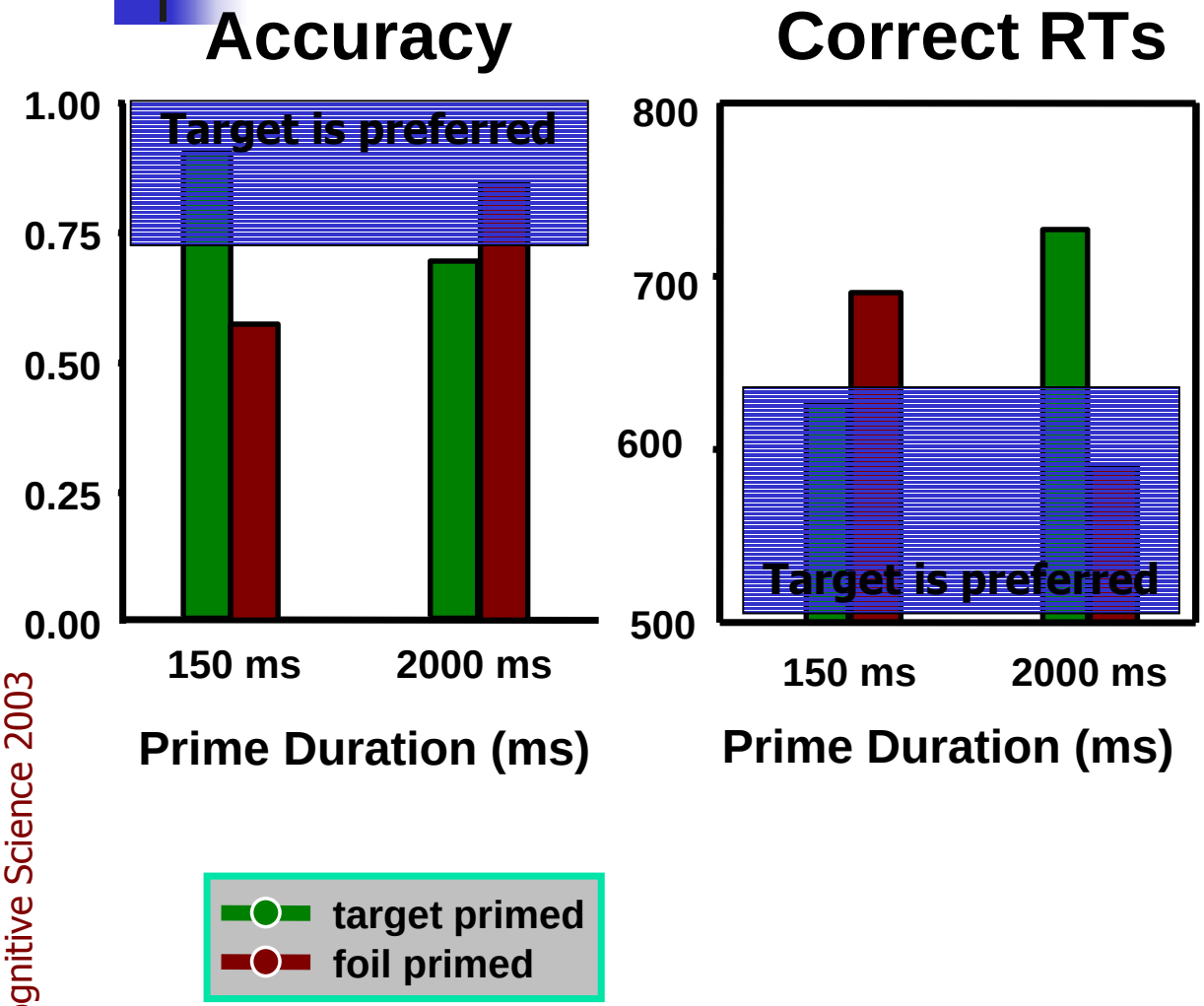
Test display

Presentation Sequence

2- A lot of trials.

C- Experiment 2

Results a) Response times for correct responses



Choice:

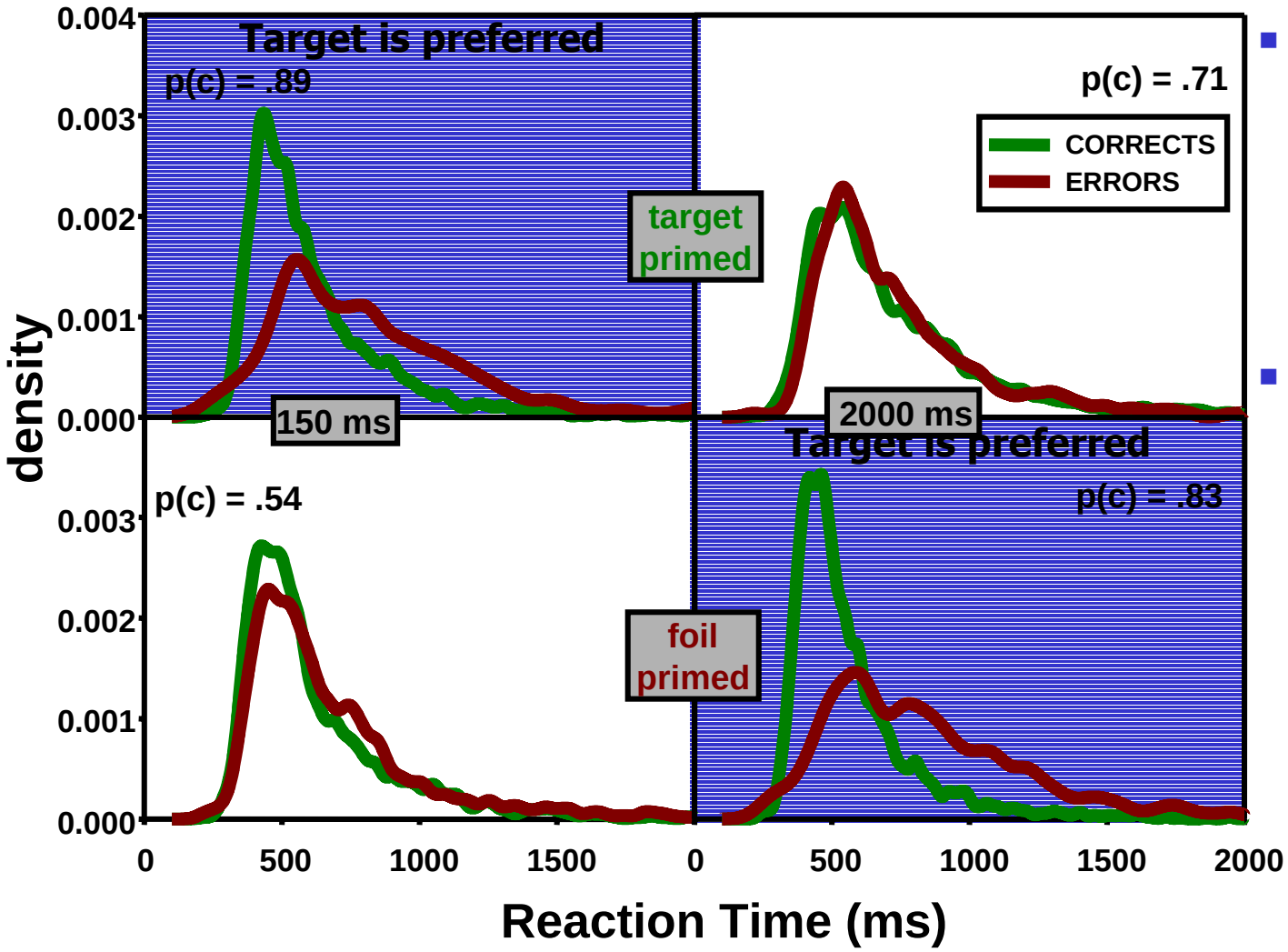
- Same preferences, with a reversal for long prime duration.

RTs:

- Preferred is faster

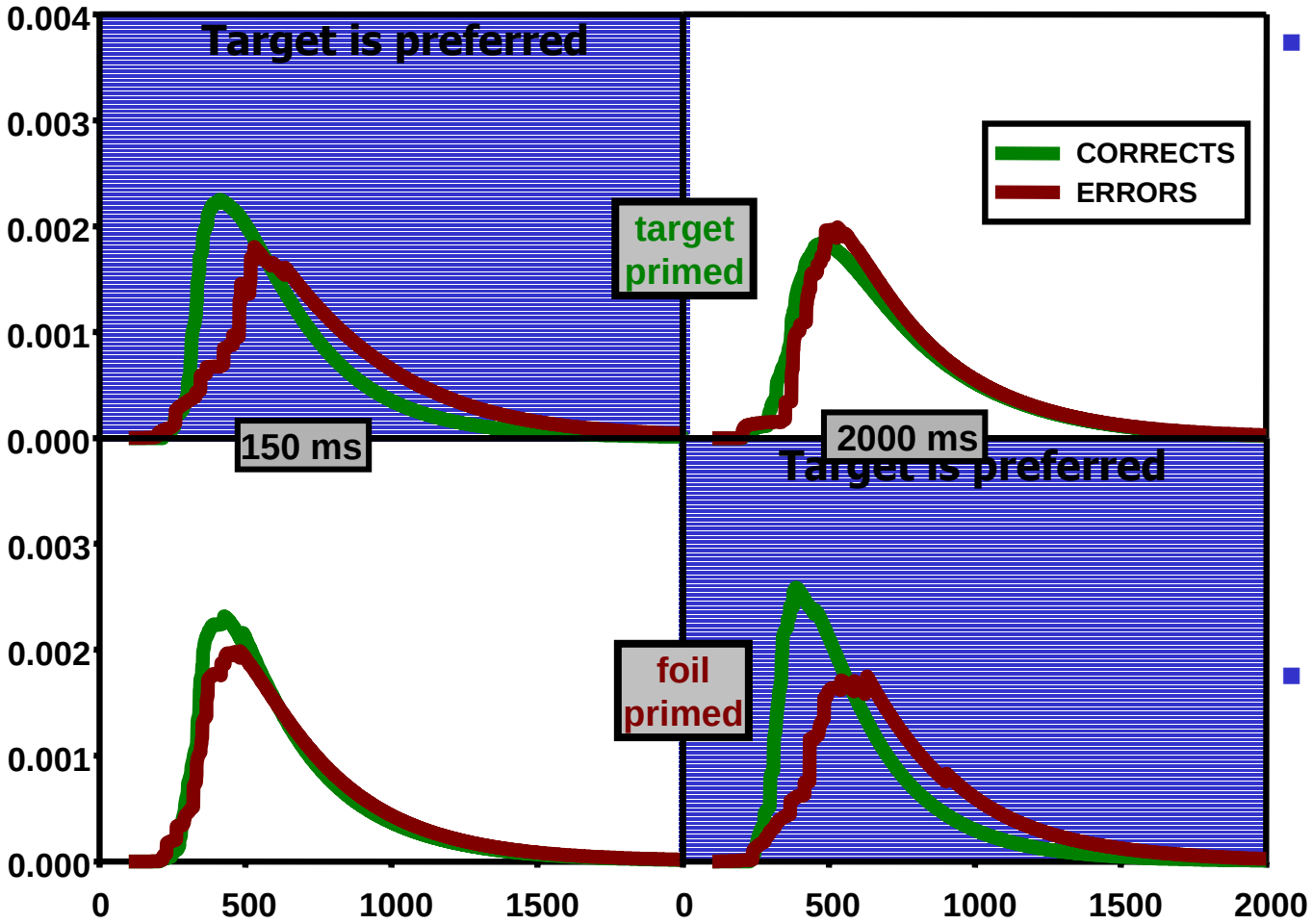
Replicates the previous findings.

C- Experiment 2
Results b) Observed distributions of RT



- The most accurate responses also have the smallest overlap.
- When the target is preferred, the scale is much smaller (favoring scenario 2).

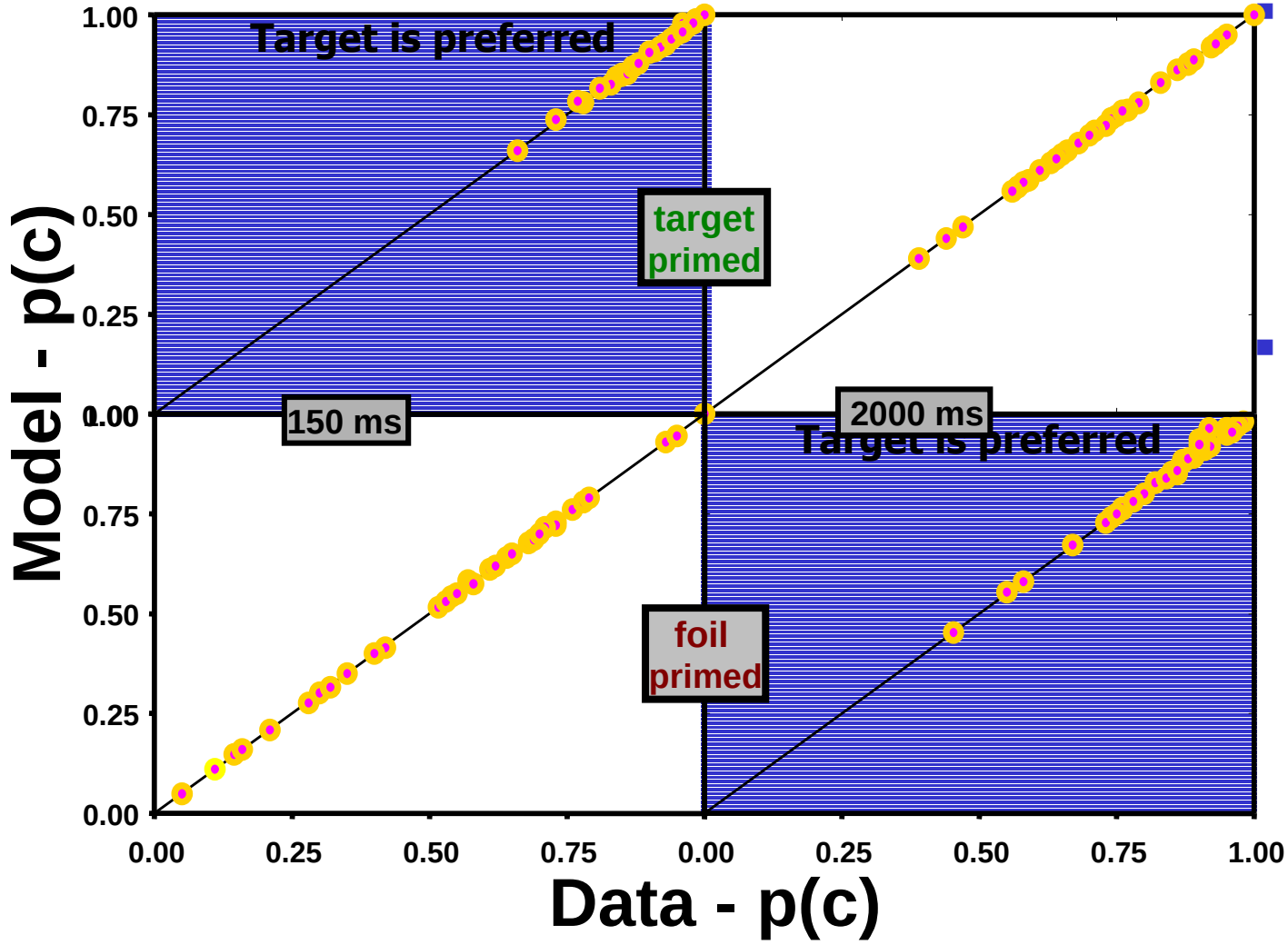
C- Experiment 2
Model a) Predicted distributions



- For each subject and each cell, given f_c and f_e, we searched for the best fitting f_1 and f_2, allowing changes in the onset (scenario 1) and the scale (scenario 2).
- Shown are f_c and f_e inferred from the model.

C- Experiment 2

Model b) Predicted error vs. observed error



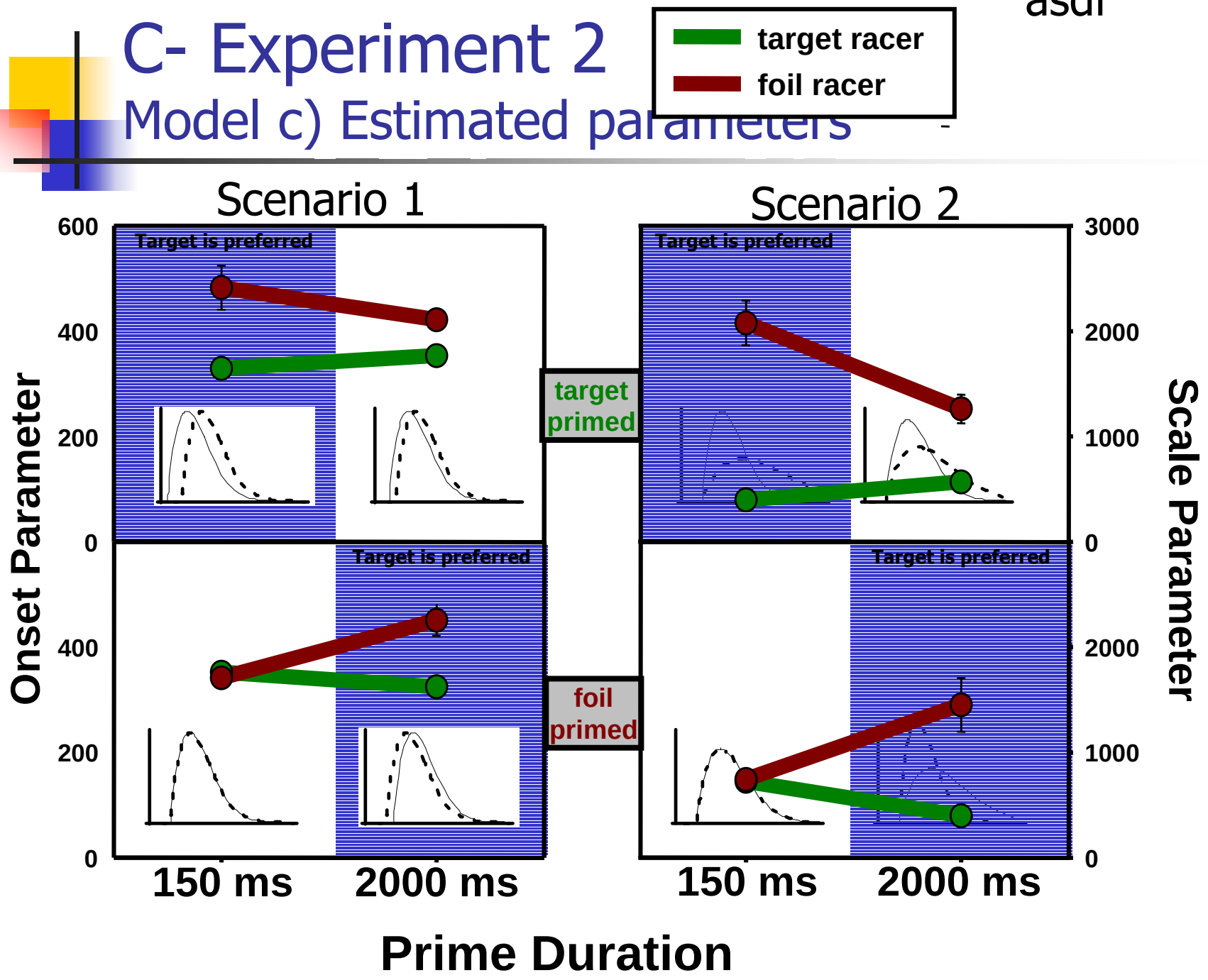
From the estimated f_1 and f_2, the percent correct can be computed

They match the data very well.

asdf

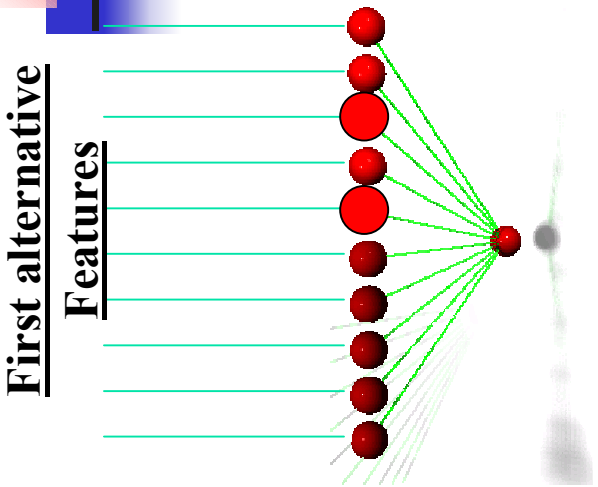
C- Experiment 2

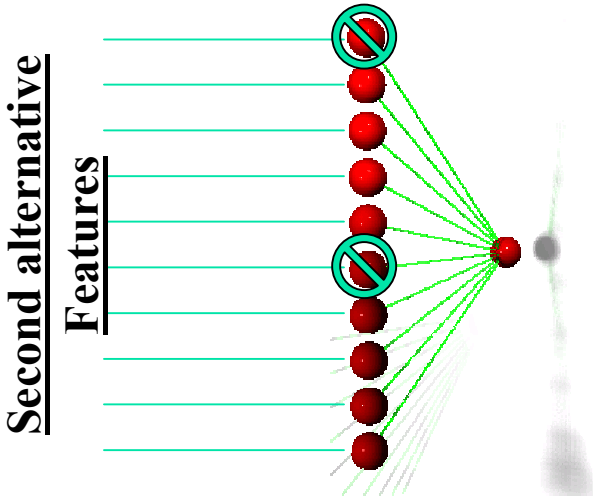
Model c) Estimated parameters



Conclusions

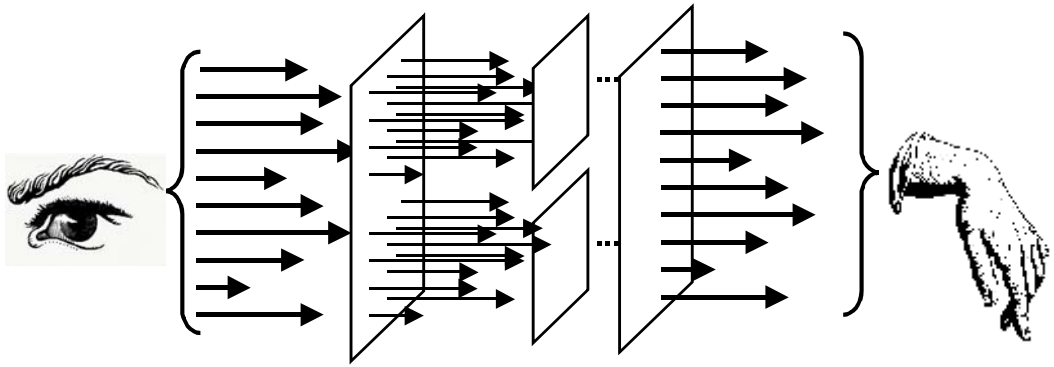
The role of synaptic fatigue





- Short activations persists in the system
  - With source confusion, it is difficult to say whether the activation comes from the prime of from the target;
- Long activations saturates the feature detectors
  - Part of the detectors being off, the other word is prefered

Concluding remarks



Not much occurs at the perceptual level;

Residual activation
➔ "cognitive facilitation"

Facilitations create preferences (biases) that can cause erroneous responses

The ubiquitous presence of priming?

Thanks.

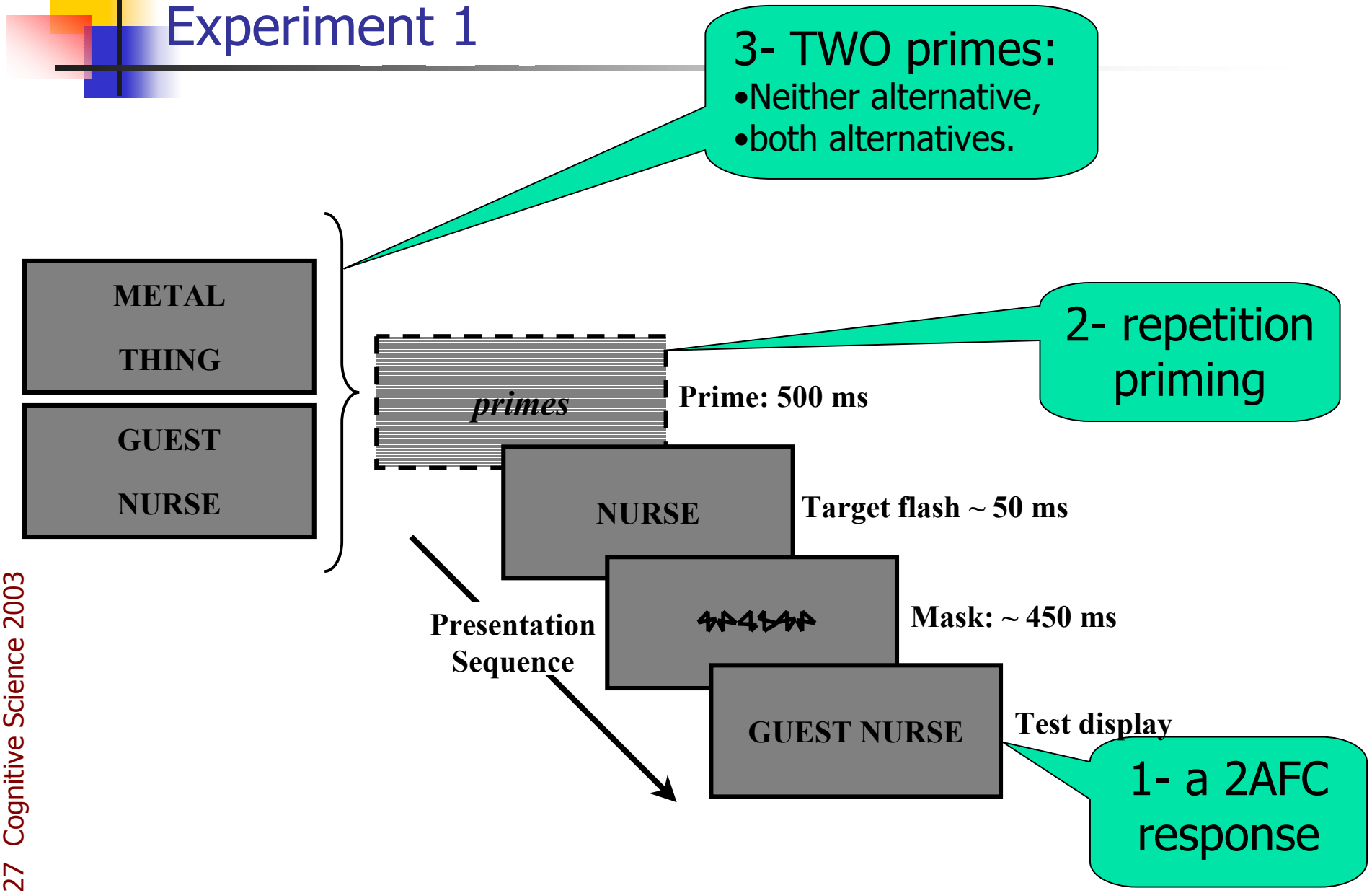
This presentation is available at:

http://mapageweb.umontreal.ca/cousined/home/talks.html

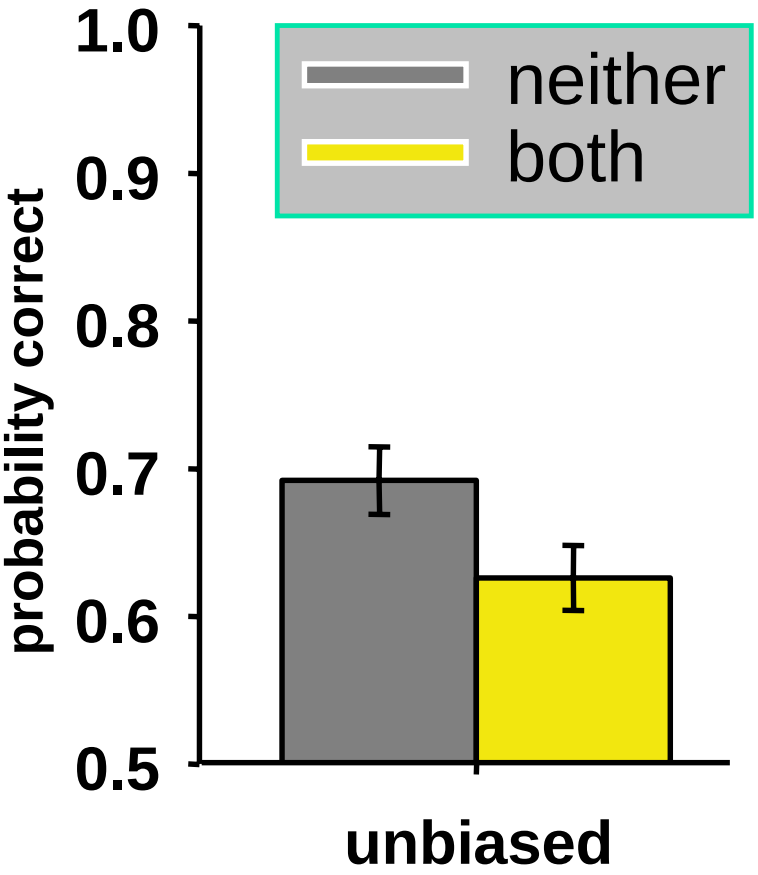
Appendix: Perceptual facilitation?

Perceptual facilitation?

Experiment 1



Perceptual facilitation?
Results a) perceptual facilitation



- If there is perceptual facilitation when the target is presented (as in the "both primed" condition),
  then P(c) should be larger than when it is not present.
- The reverse is observed: a "Both primed" deficit
- No evidence of perceptual facilitation.