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?

Overview

- 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

A- Experiment 1
  - Choice preferences

B- Race model of RTs

C- One test of the model
A- Experiment 1
A- Experiment 1

Method

1- a 2AFC response

2- Duration varied

3- repetition priming

4- Two conditions
   - target primed,
   - foil primed

Presentation Sequence

primes

Prime: 17 .. 2000 ms

Target flash ~ 50 ms

Mask: ~ 450 ms

Test display

1- Two conditions
   - target primed,
   - foil primed

2- Duration varied

3- Repetition priming

4- Two conditions
   - target primed,
   - foil primed
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”).

Accuracy

Prime Duration log scale (ms)

Target is preferred

target primed
foil primed
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

First alternative

Features

\[ f_1(t) = \Pr(T_1 < t) \]

\[ f_c(t) = \Pr(T_1 < T_2) \]

Assuming that the target is the first alternative:

\[ f_c(t) = \Pr(T_1 = t \& T_2 > t) \]

\[ = \Pr(T_1 = t) \Pr(T_2 > t) \]

\[ = \Pr(T_1 = t) \Pr(T_2 > t) \]

\[ = f_1(t)(1 - F_2(t)) \]

\[ P(c) = \int_{\forall t} f_c(t) dt \]

\[ = \int_{\forall t} f_1(t)(1 - F_2(t)) dt \]

\[ \text{analytic} \]

 Second alternative

Features

\[ f_2(t) = \Pr(T_2 < t) \]

\[ f_E(t) = \Pr(T_2 < T_1) \]

\[ \text{best-fit} \]

\[ P(c) = 75\% \]

\[ \text{Mean}(c) = 43 \]

\[ \text{Mean}(e) = 51 \]
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

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

Presentation

Sequence

Prime 150 or 2000 ms

NURSE

GUEST

GUEST

NURSE

NURSE

GUEST

GUEST

10 100 1000

Prime Duration

log scale (ms)

Accuracy

0.00 0.25 0.50 0.75 1.00

Probability Correct

1- Only 2 durations

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.
C- Experiment 2
Model c) Estimated parameters

Scenario 1
- Prime Duration
  - 150 ms
  - 2000 ms
  - Target is preferred

Onset Parameter
- 0
- 200
- 400
- 600

Scale Parameter
- 0
- 1000
- 2000
- 3000

Scenario 2
- Prime Duration
  - 150 ms
  - 2000 ms
  - Target is preferred

Onset Parameter
- 0
- 1000
- 2000

Scale Parameter
- 0
- 1000
- 2000

Legend:
- target racer
- foil racer

Notes:
- Scenario 1: Target is preferred
- Scenario 2: Target is preferred
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 or 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 \(\Rightarrow\) “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

1- a 2AFC response

2- repetition priming

3- TWO primes:
   • Neither alternative,
   • both alternatives.

Presentation Sequence

Prime: 500 ms

Target flash ~ 50 ms

Mask: ~ 450 ms

Test display

primes

NURSE

GUEST NURSE

GUEST

METAL

THING

NURSE

NURSE

GUEST NURSE
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.