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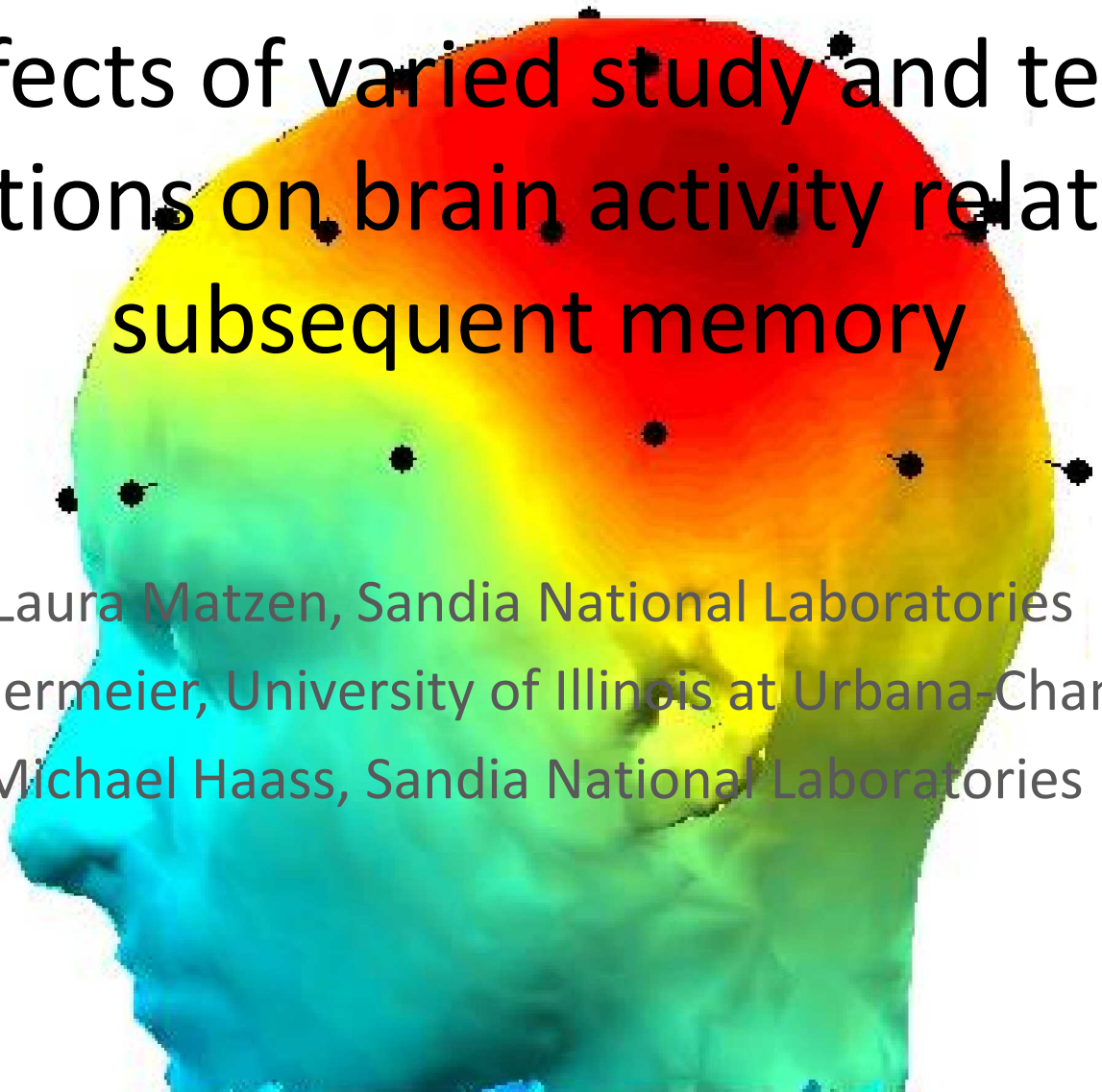
SAND2011-4579C

Effects of varied study and test conditions on brain activity related to subsequent memory



Laura Matzen, Sandia National Laboratories

Kara Federmeier, University of Illinois at Urbana-Champaign

Michael Haass, Sandia National Laboratories

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Background

- Goal of study:
  - Use event-related potentials (ERPs) to assess performance during learning and memory tasks
    - What patterns of brain activity at study are associated with the best performance at test?
      - Repetition effects
      - Dm effects
    - Can ERPs indicate whether people are using an effective study strategy?

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Overview of the Dm Effect

- Difference related to subsequent memory

- Words studied while EEG is recorded:

  fight, alarm, cut, nation, storm, fire, noon…

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Overview of the Dm Effect

- Difference related to subsequent memory

- At test: Words are **REMEMBERED** or **FORGOTTEN**

  fight, alarm, cut, nation, storm, fire, noon…

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Overview of the Dm Effect

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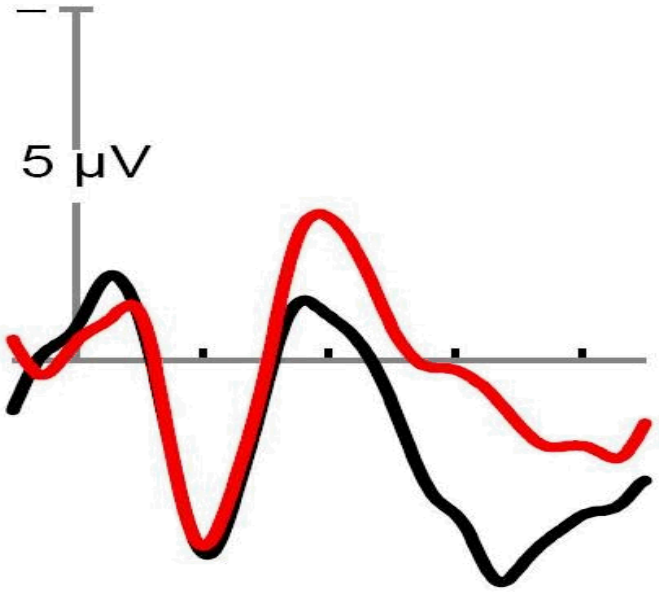
Event-related potentials (ERPs) from STUDY are sorted by memory performance:

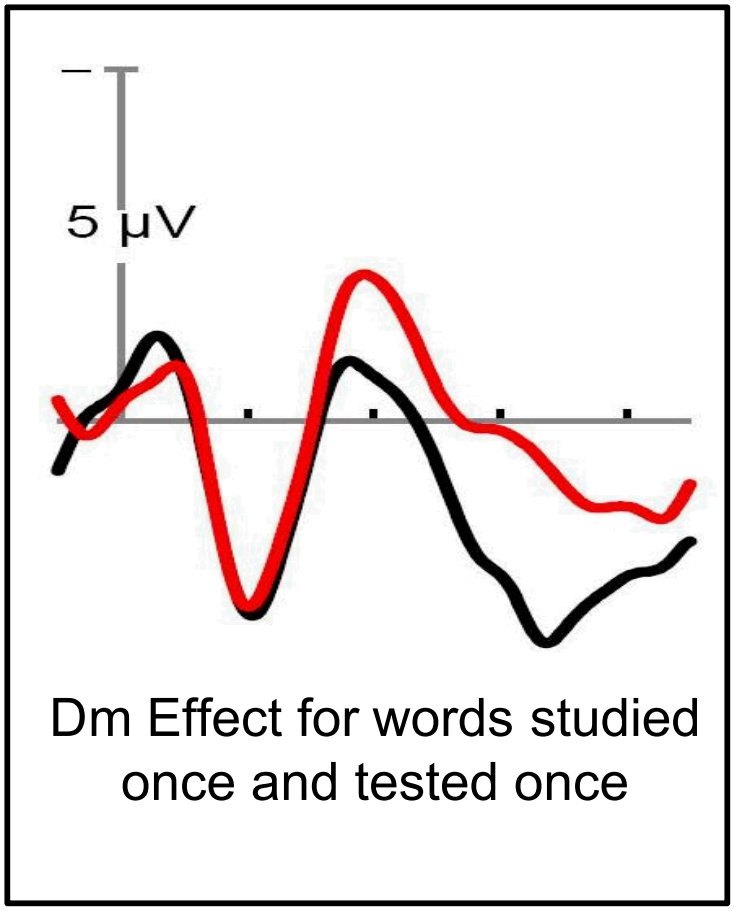
Words that will be remembered later more positive than words that will be forgotten



Overview of the Dm Effect

- Dm Effect suggests that brain activity recorded at study can be predictive of later memory performance

- Which aspects of the encoding signal are predictive of later memory under more complex encoding conditions?



Dm Effect for words studied once and tested once

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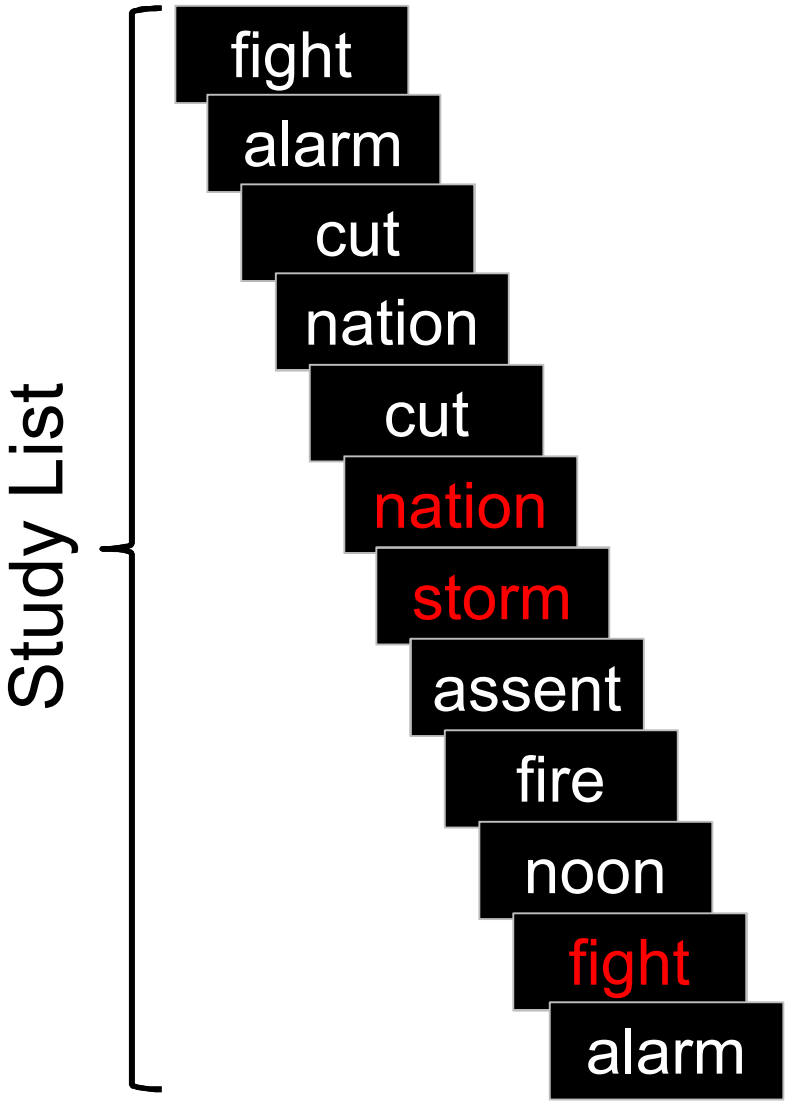

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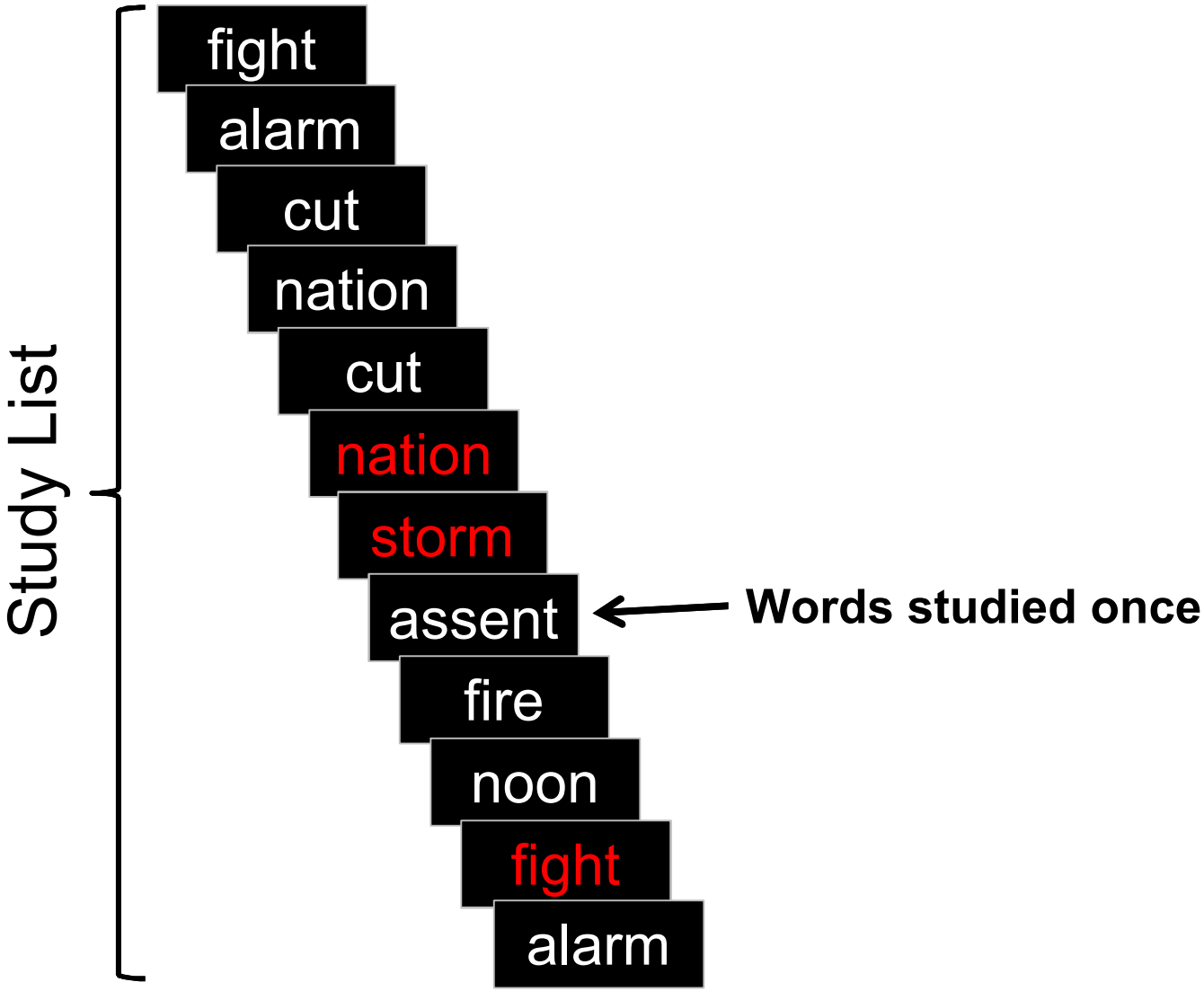

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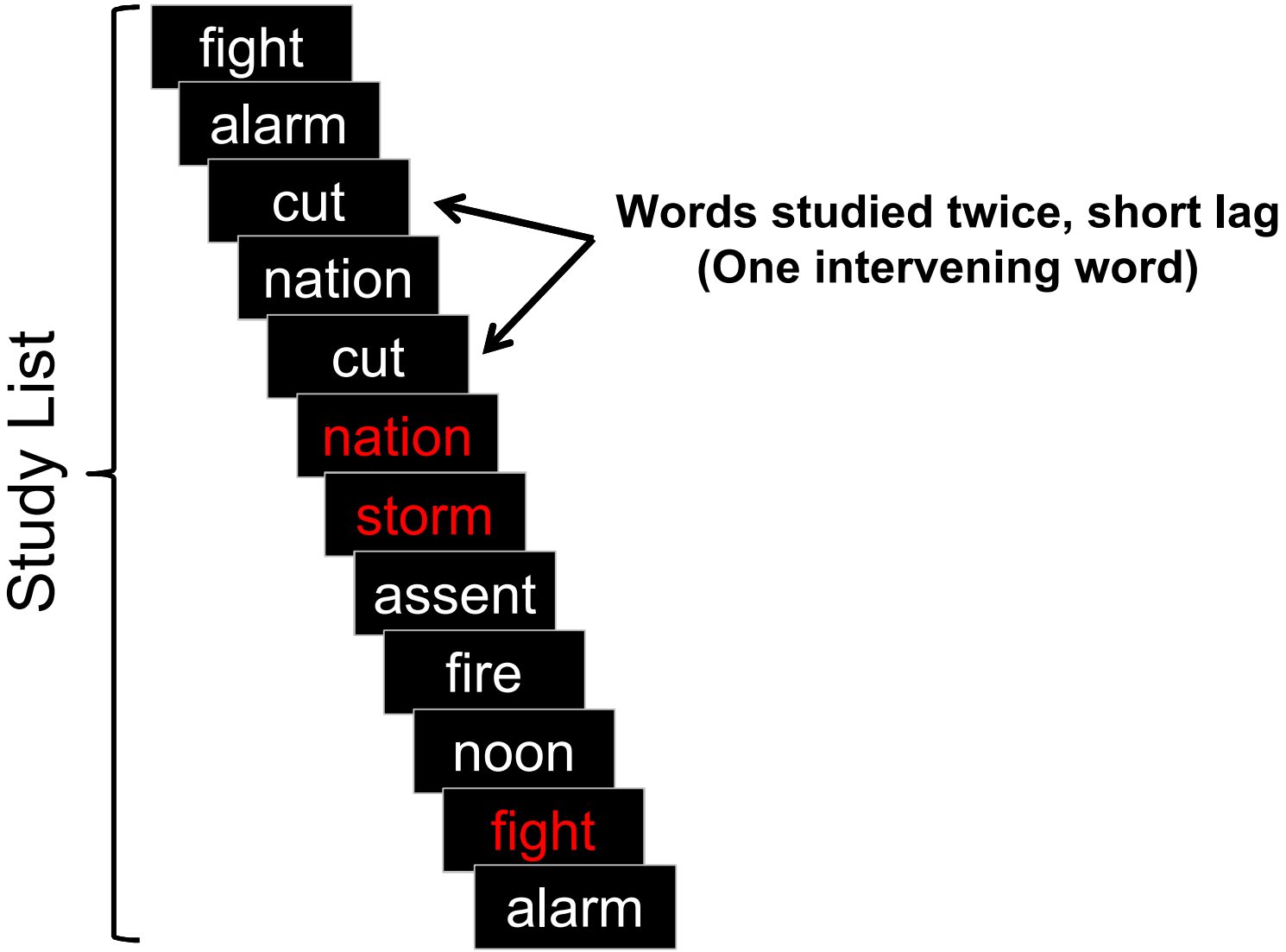

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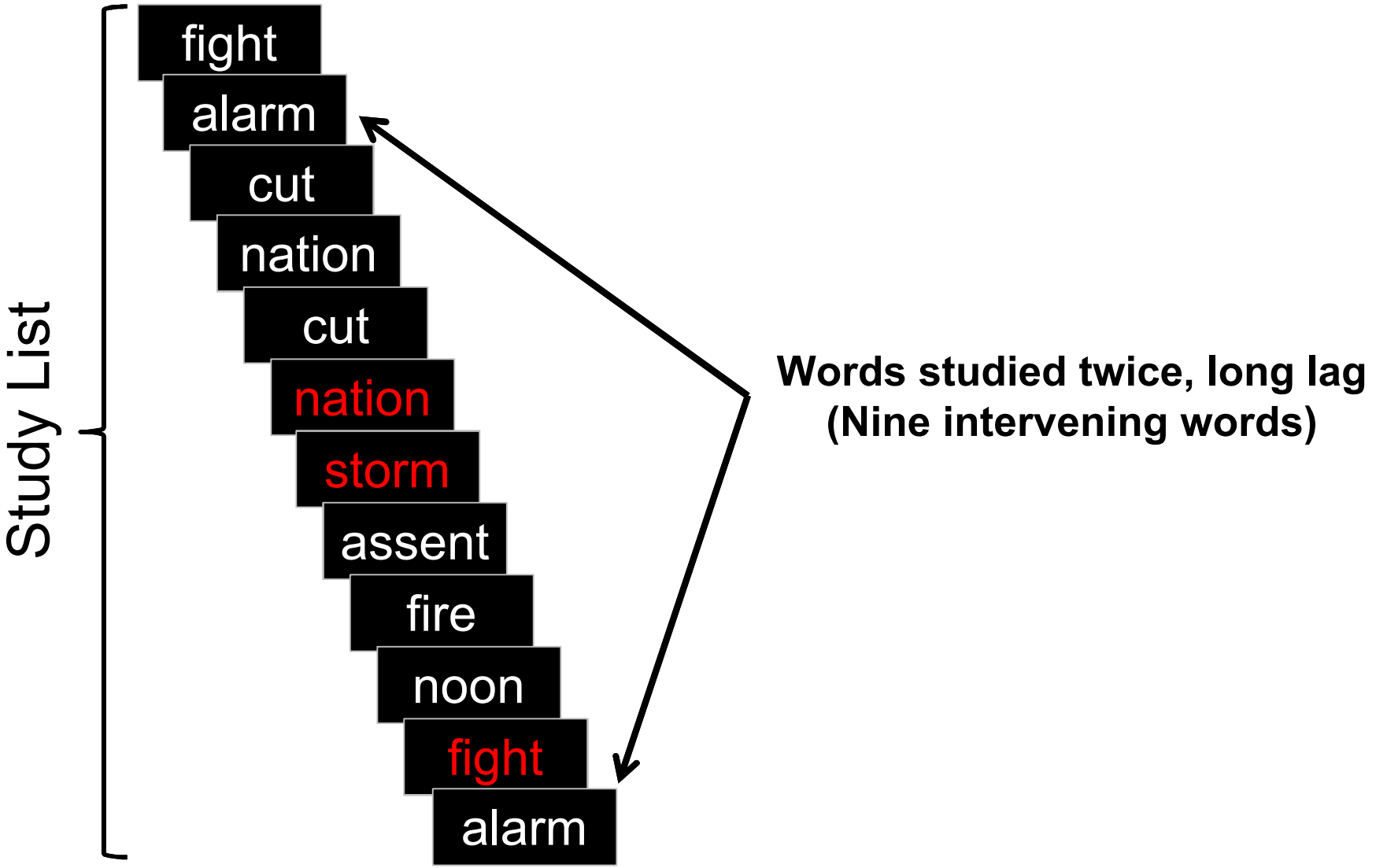

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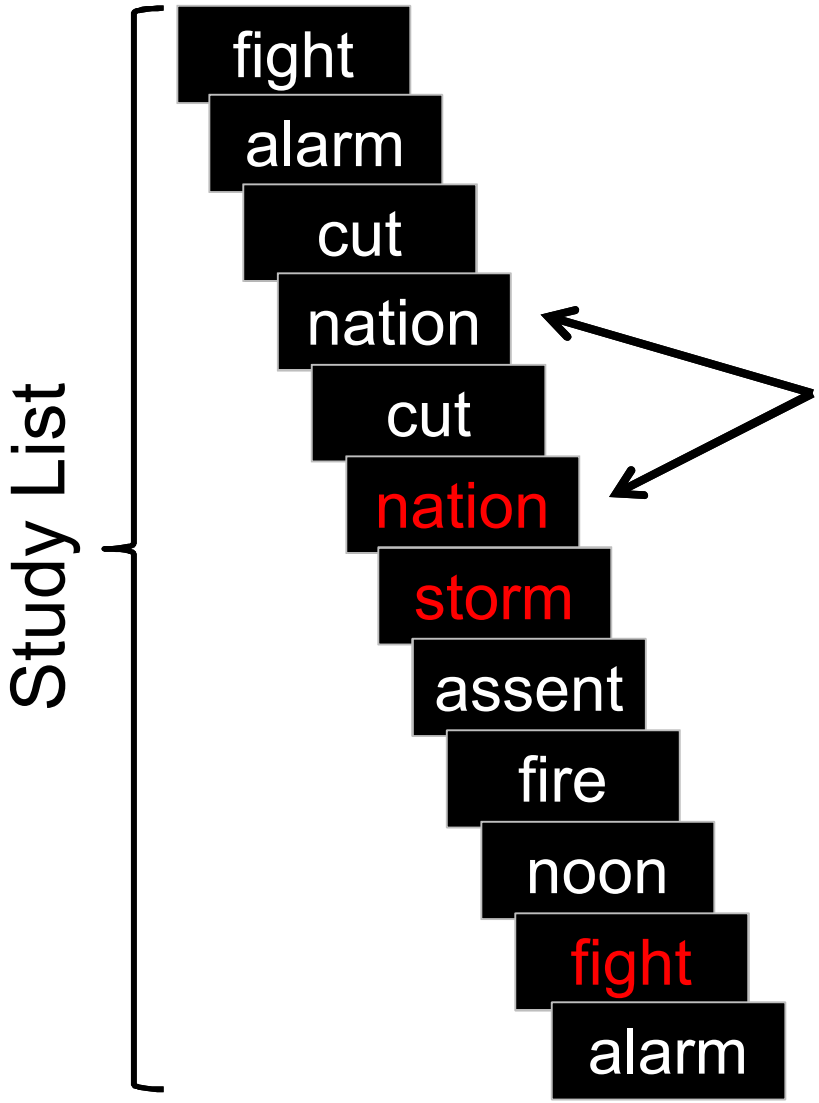

Words studied and tested, short lag (One intervening word)

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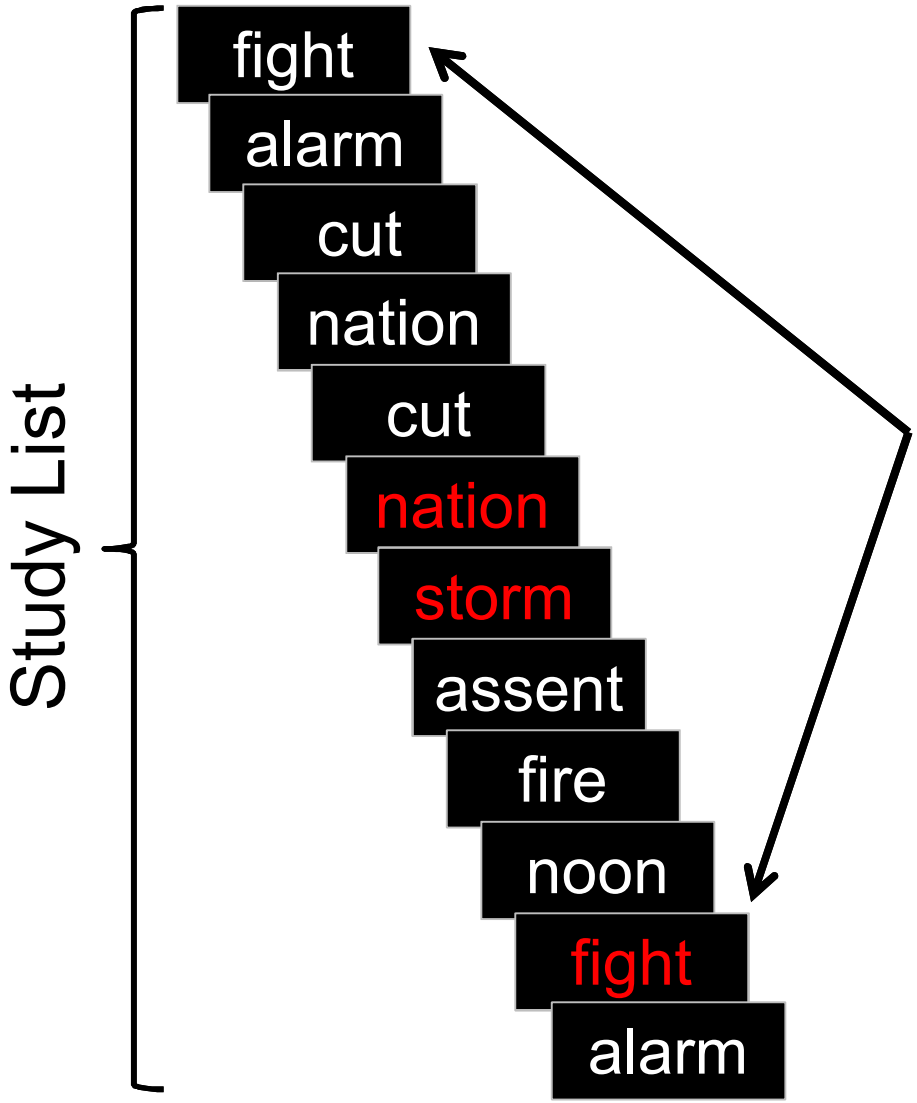

Words studied and tested, long lag
(Nine intervening words)

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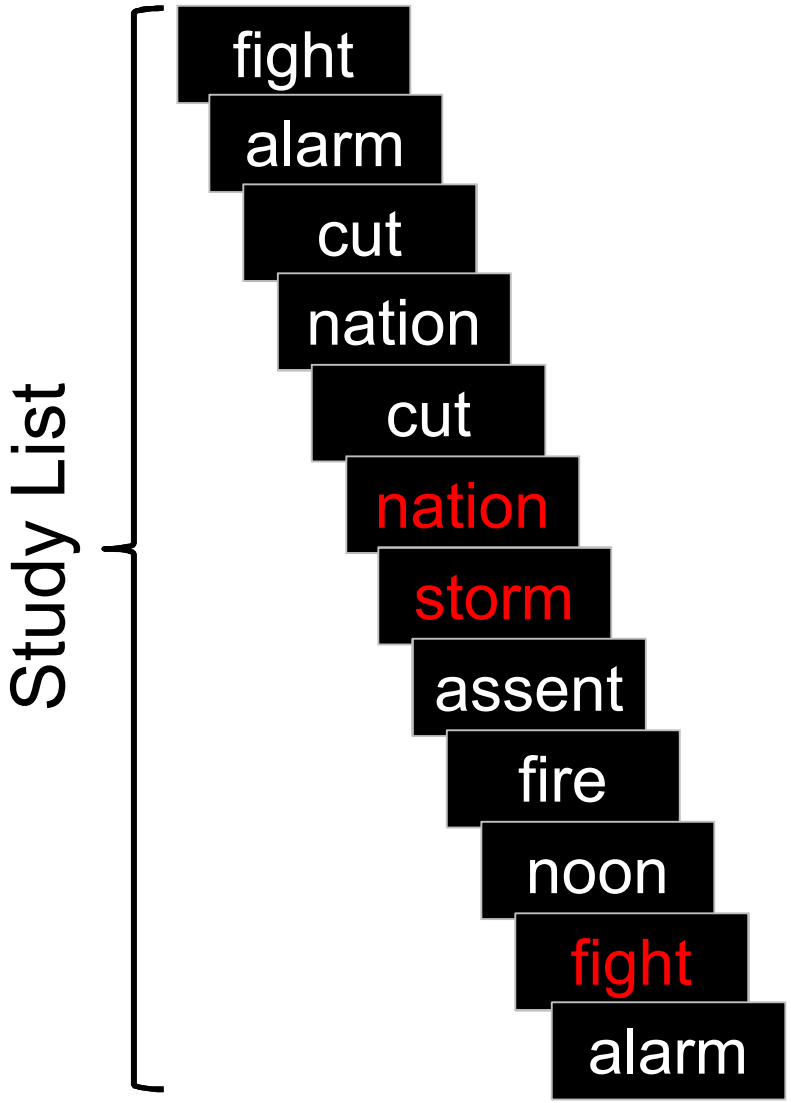

Subsequent Test

- Items from all conditions tested (or retested), along with an equal number of new, unstudied items

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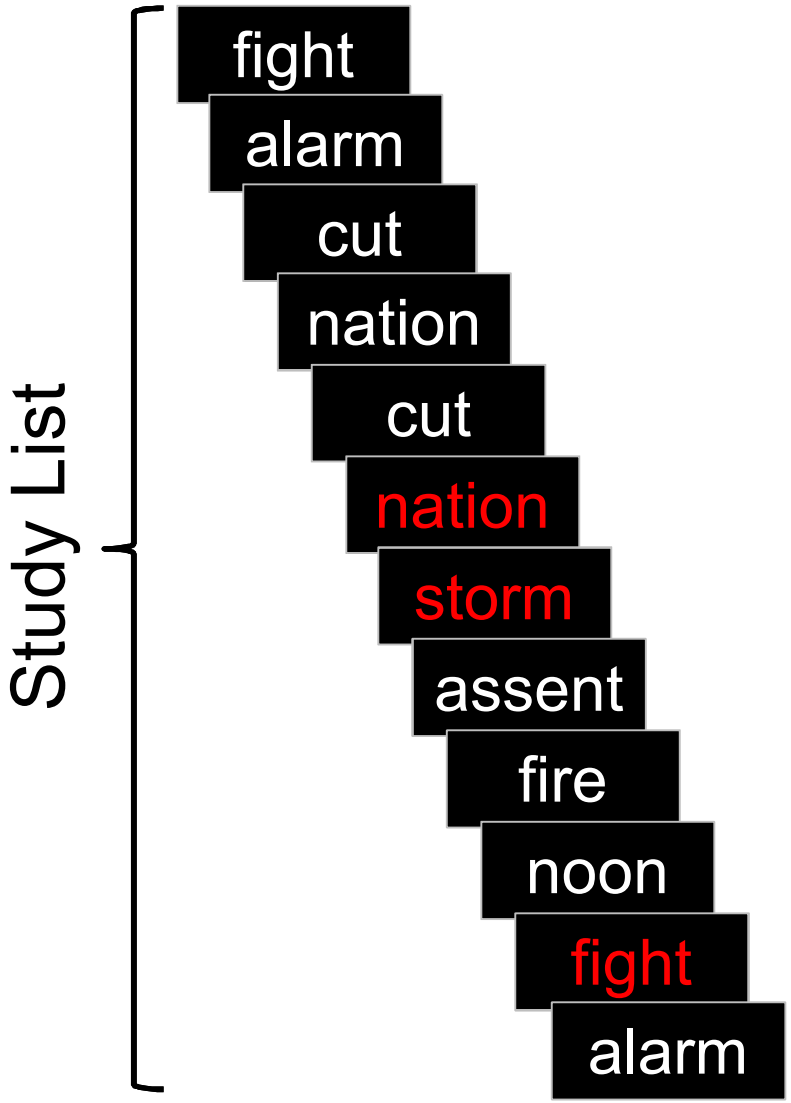

Predictions

- Better memory at test for words quizzed during study
- Better memory at test for spaced repetitions

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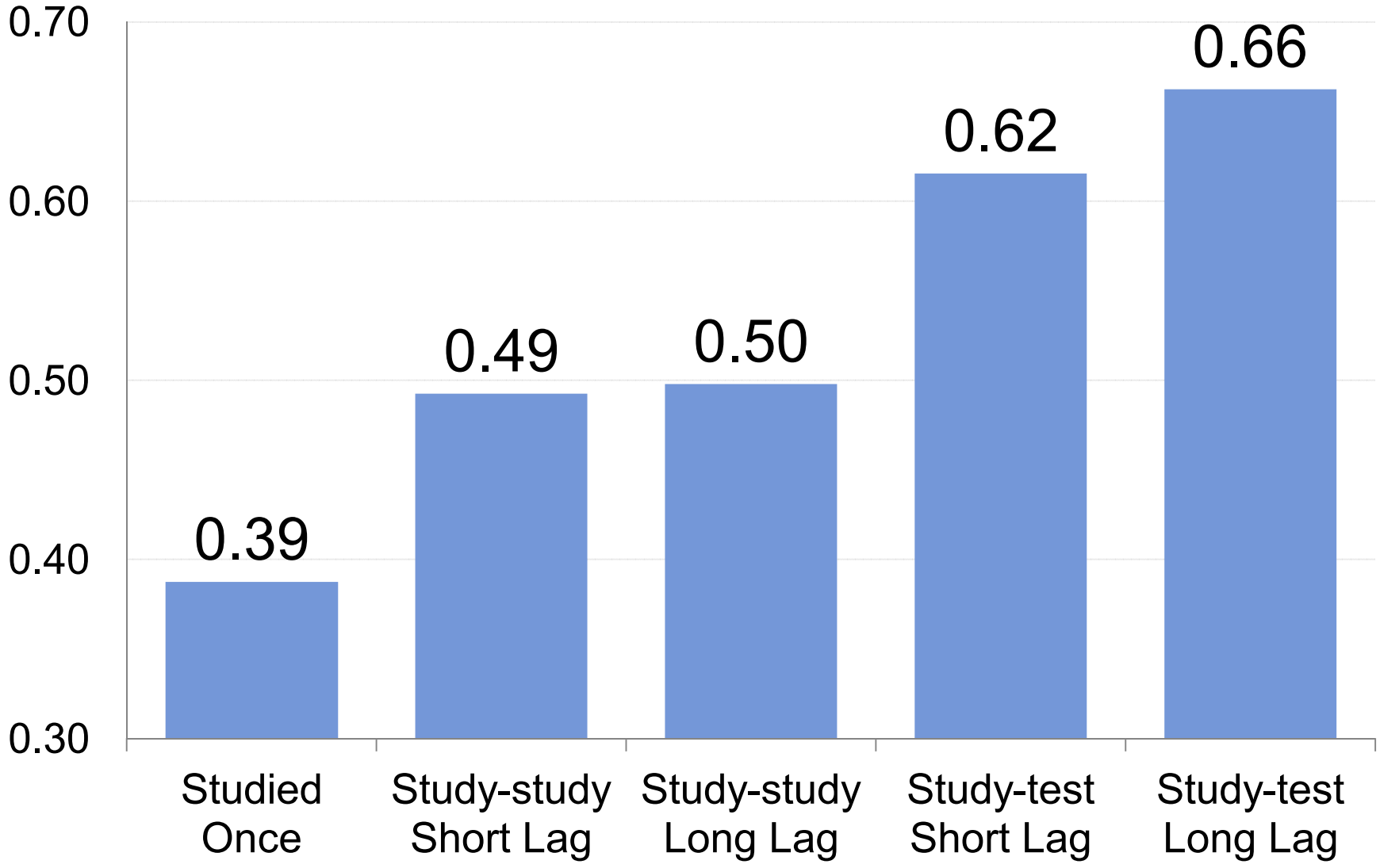
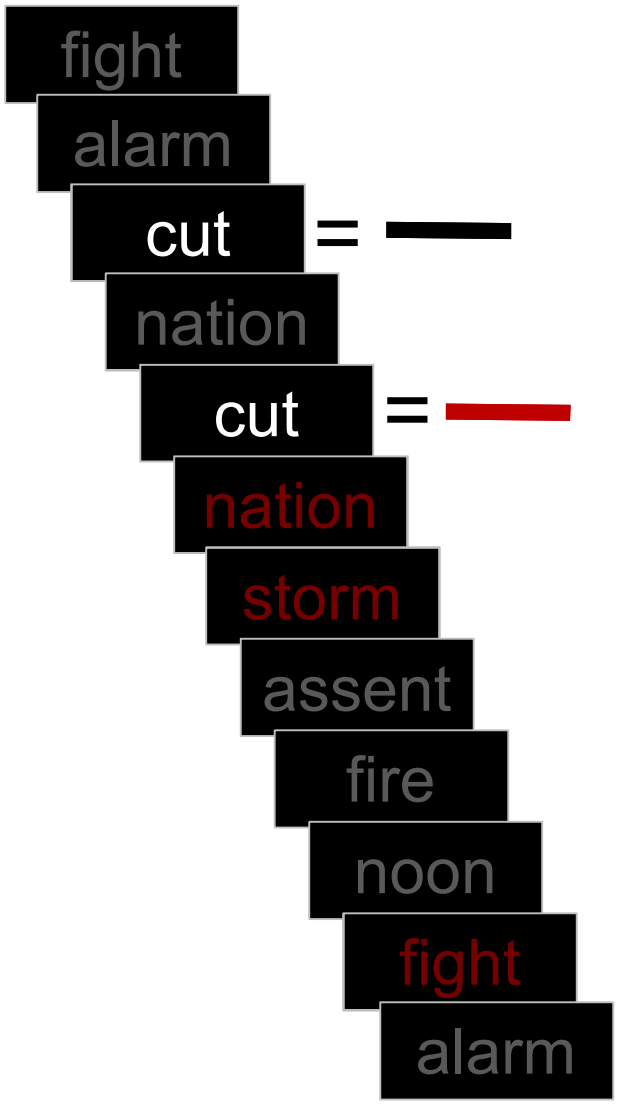
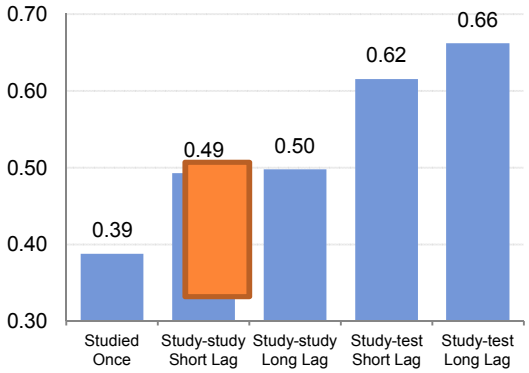
Behavioral Results



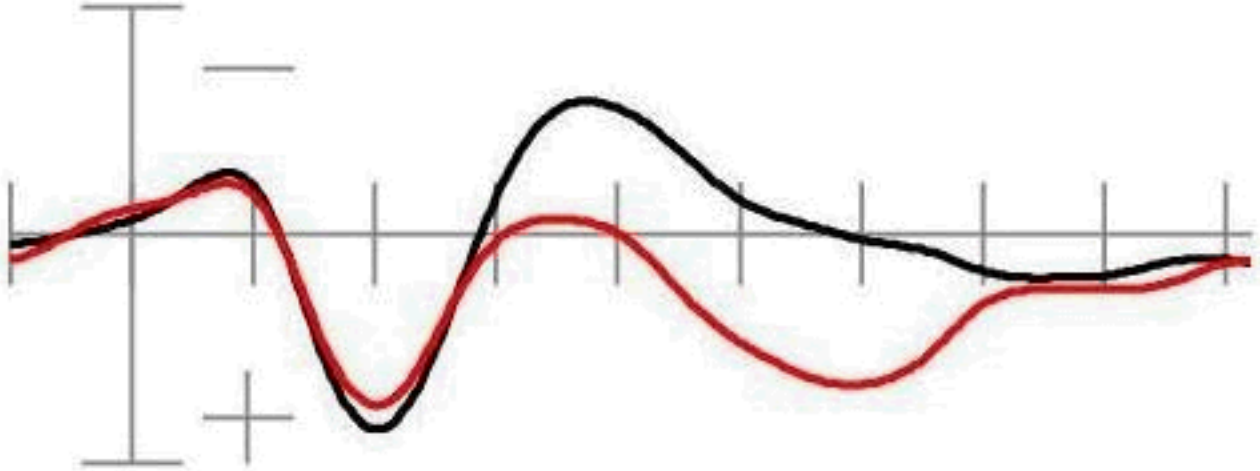
Repetition effects during study

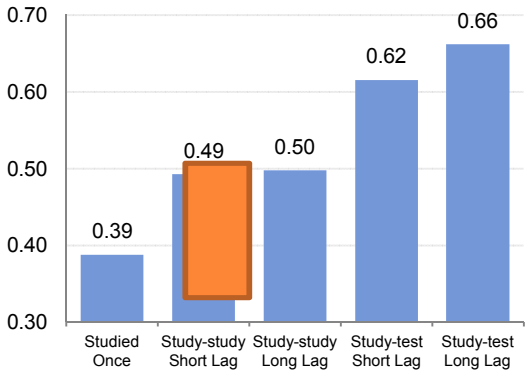




Repetition effects during study

fight
alarm
cut = —
nation
cut = —
nation
storm
assent
fire
noon
fight
alarm





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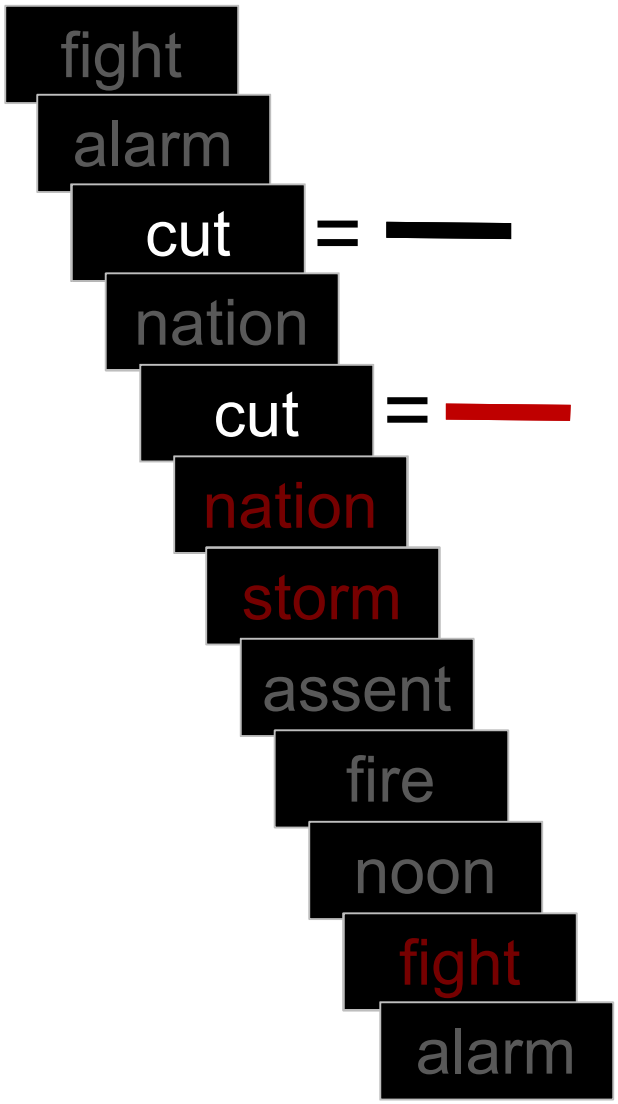

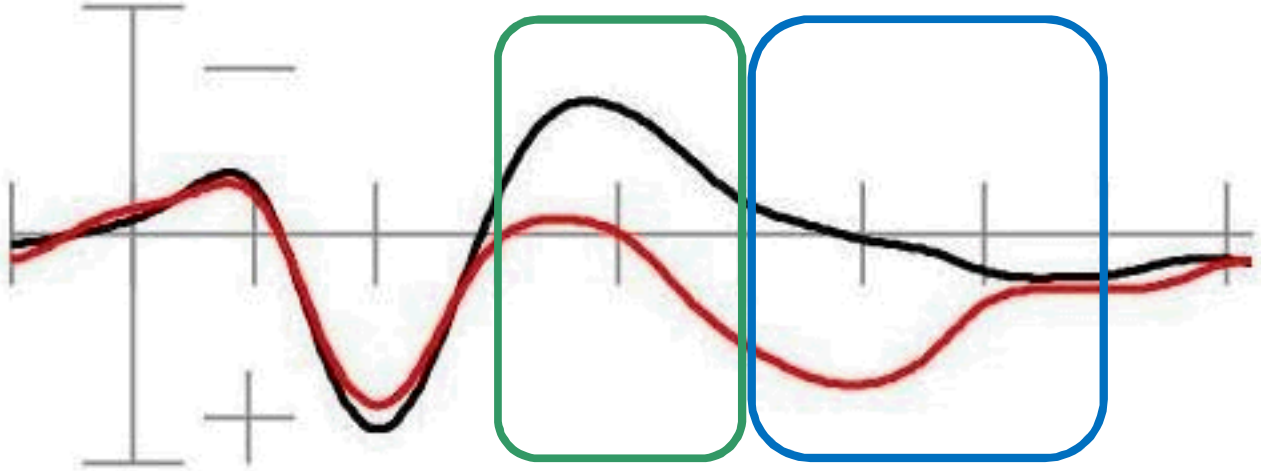

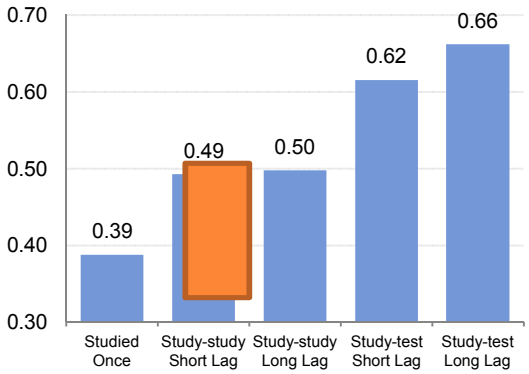

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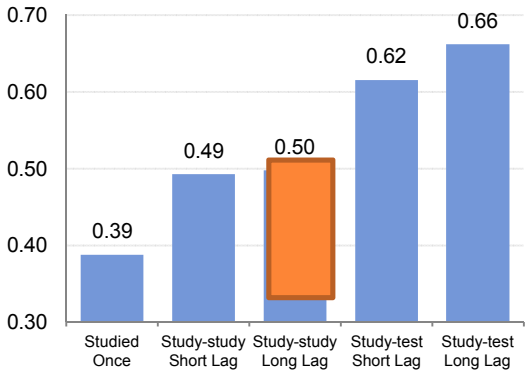

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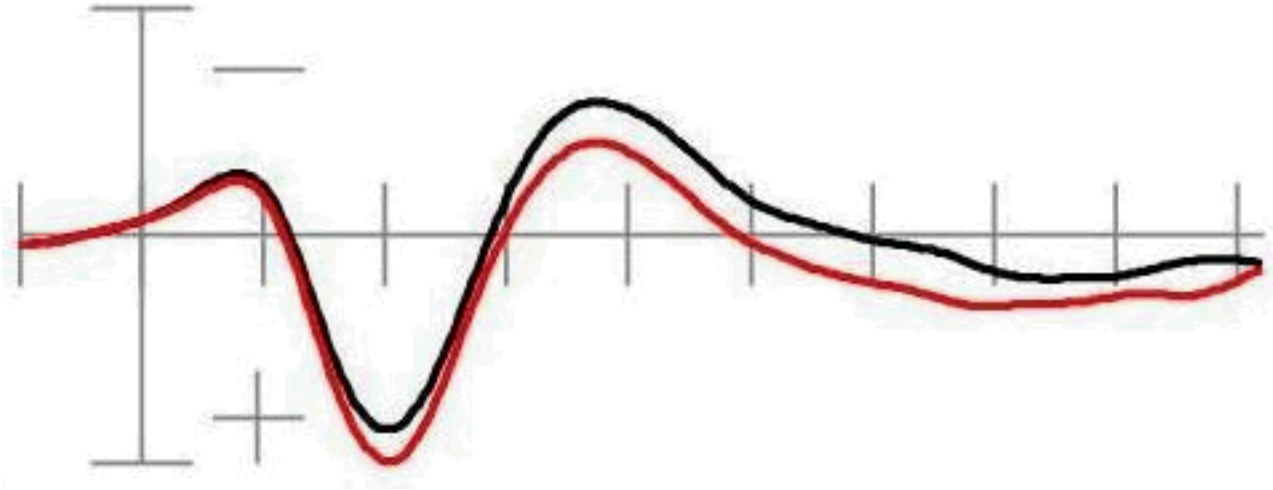

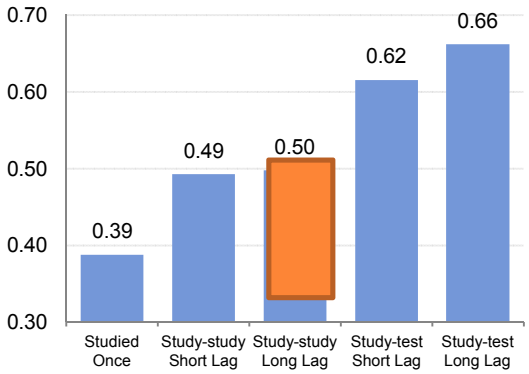

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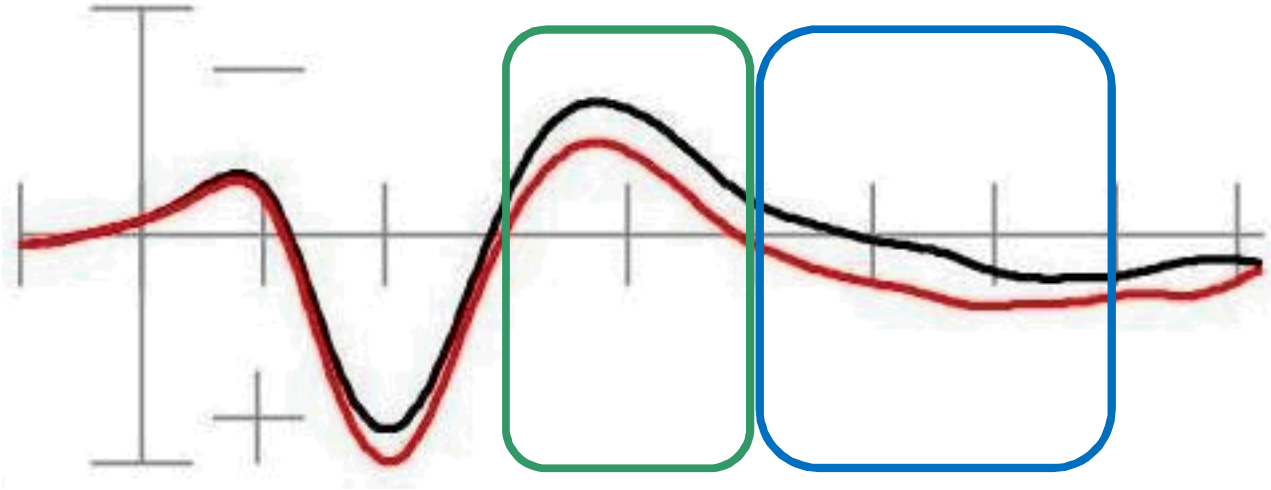

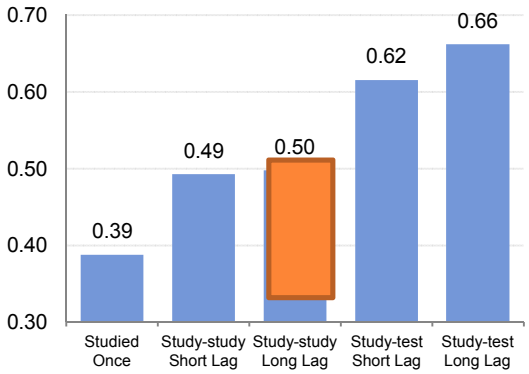

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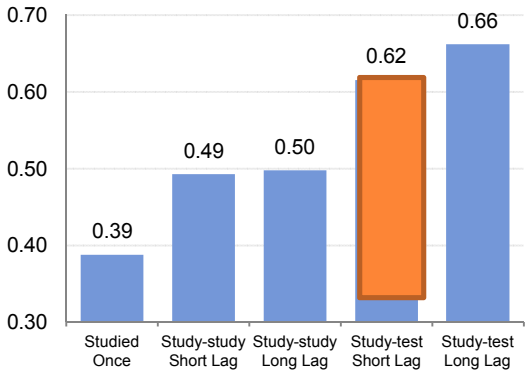

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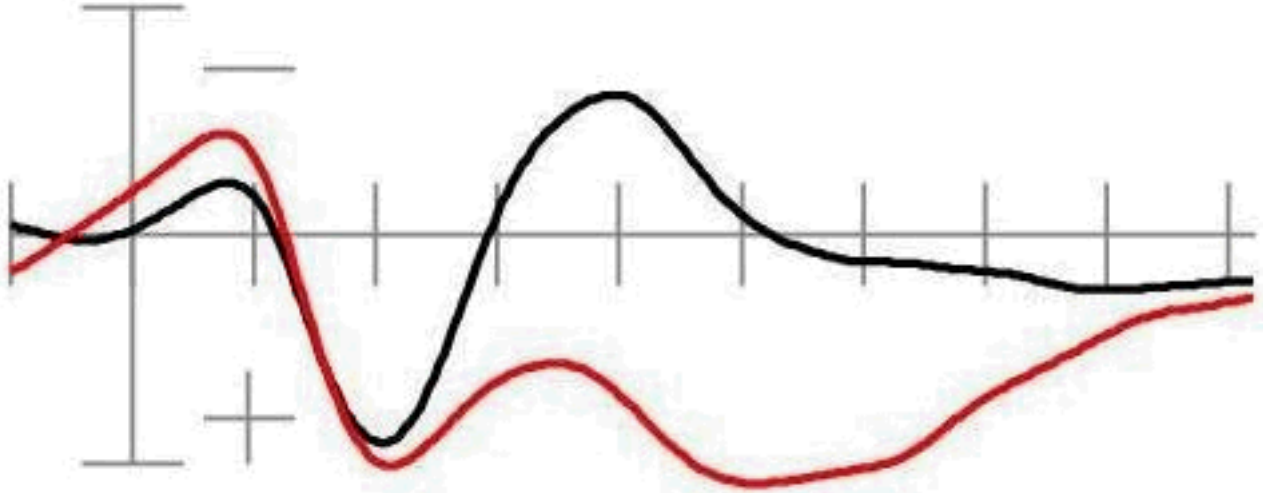

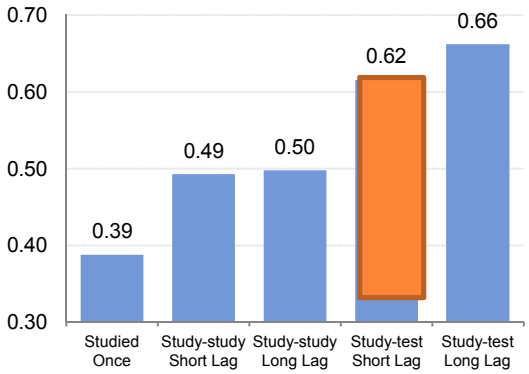

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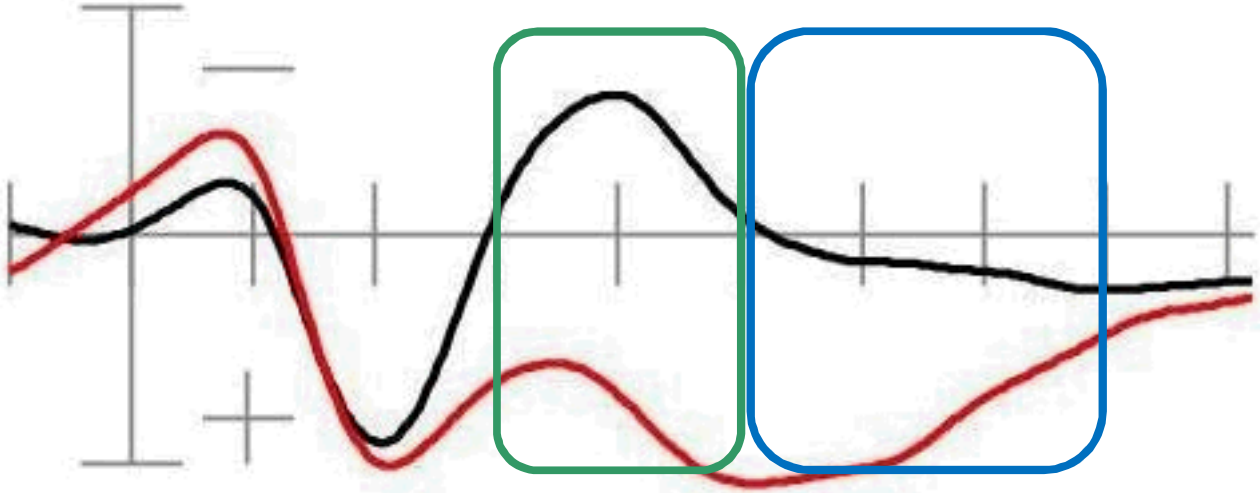

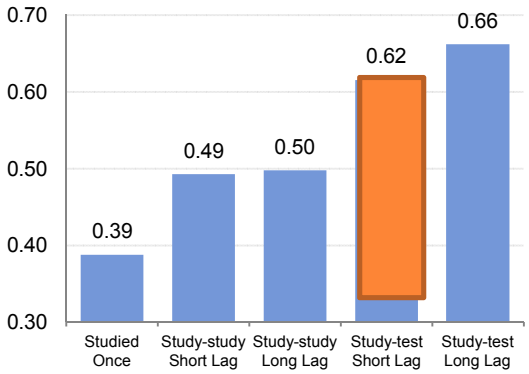

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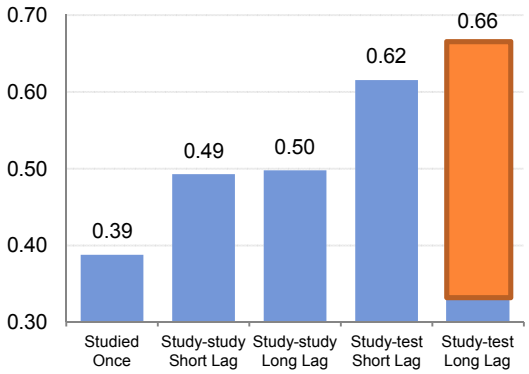

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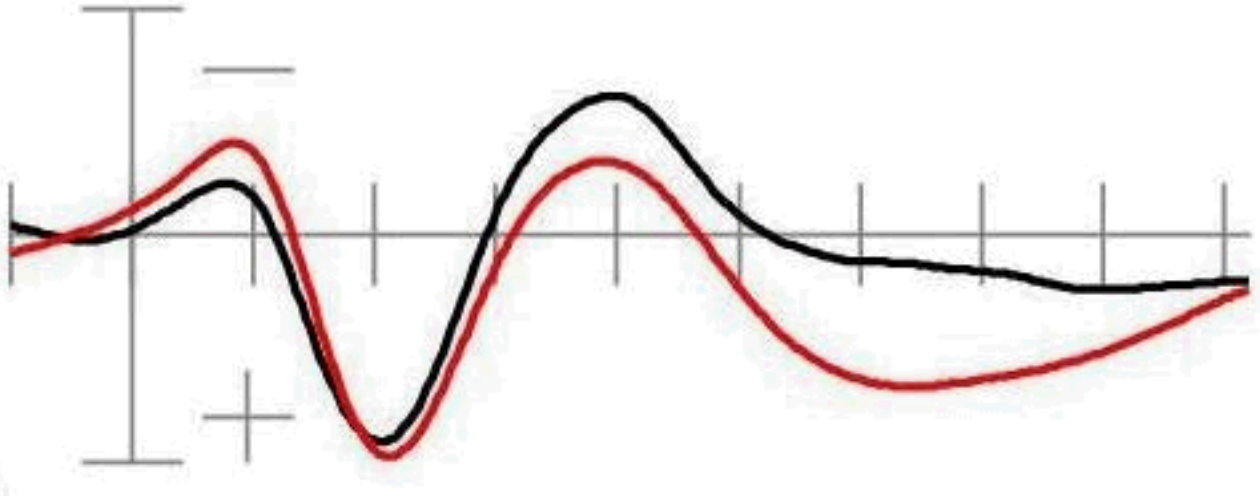

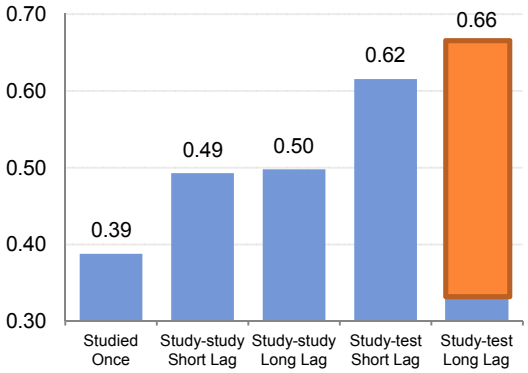

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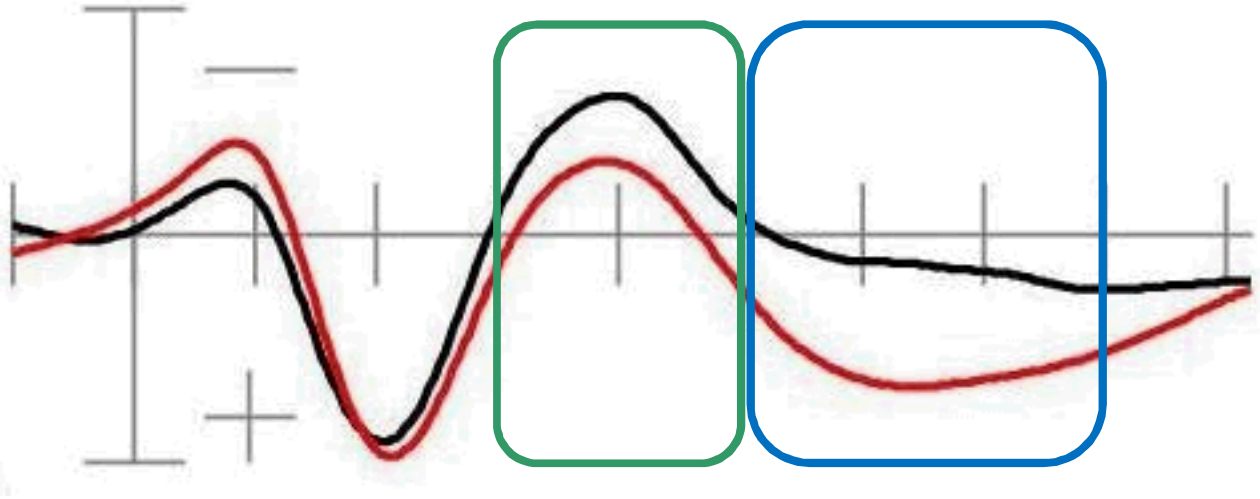

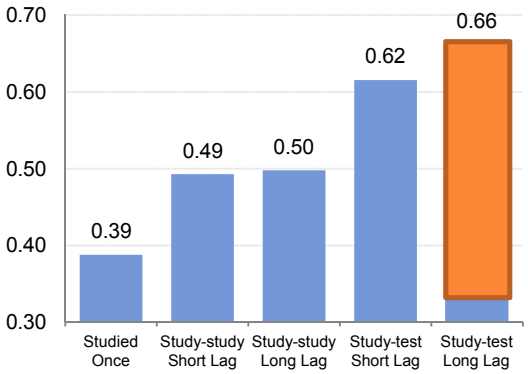

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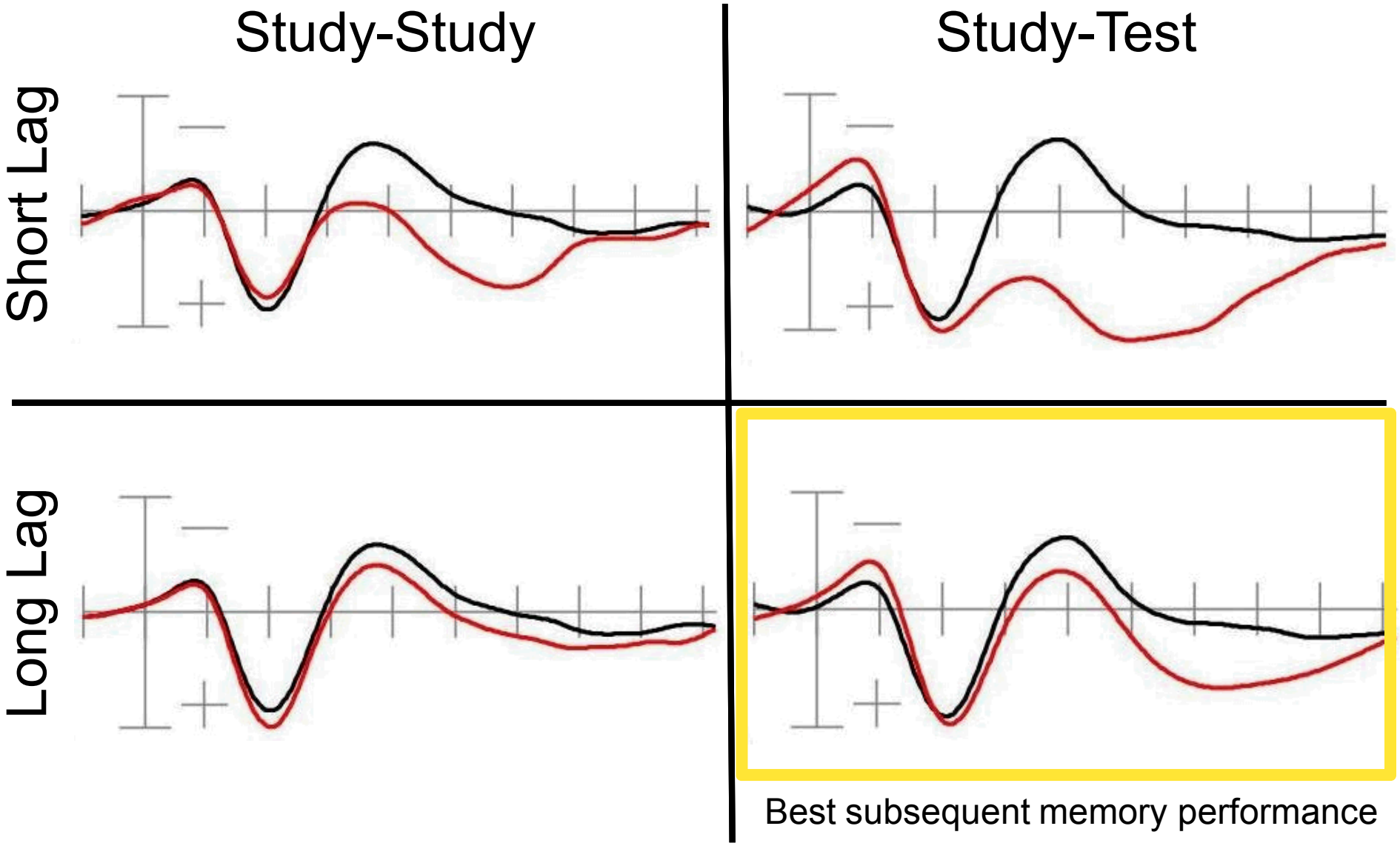
Repetition effects during study



Best subsequent memory performance

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Summary of Repetition Effects

- N400 repetition effect at short lags
  - Implicit memory for repeated word
- LPC elicited by short lag repetitions and by explicit testing
  - Explicit search of memory/recollection of studying word previously
- Best behavioral memory performance associated with LPC (explicit memory) in absence of N400 facilitation (implicit memory)
- But what about the twice-studied items?
  - No behavioral spacing effect
  - No LPC elicited by long lag repetitions

Summary of Repetition Effects

- N400 repetition effect at short lags
  - Implicit memory for repeated word
- LPC elicited by short lag repetitions and by explicit testing
  - Explicit search of memory/recollection of studying word previously
- Best behavioral memory performance associated with LPC (explicit memory) in absence of N400 facilitation (implicit memory)
- How do the repetition effects relate to the Dm Effect?

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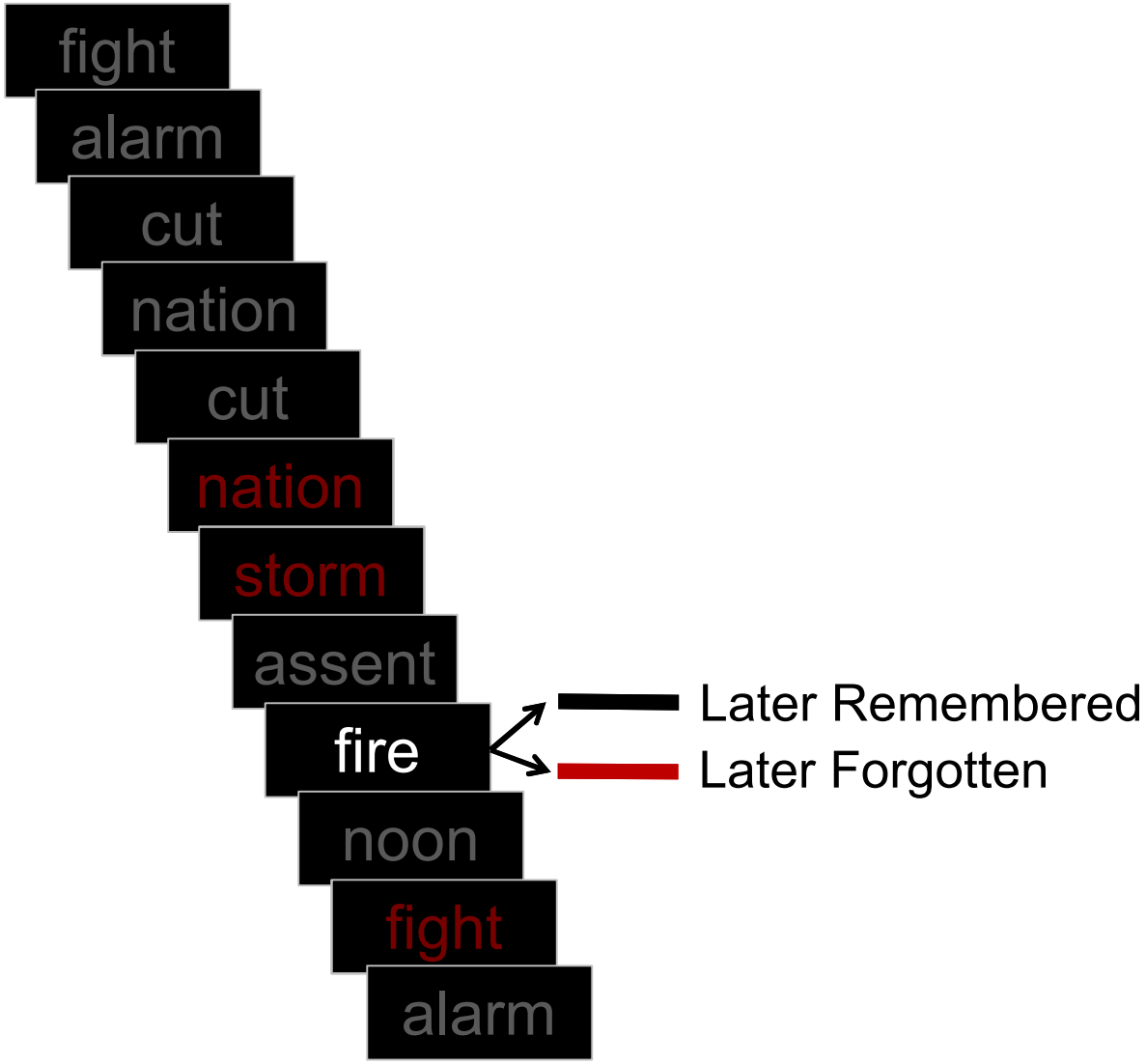
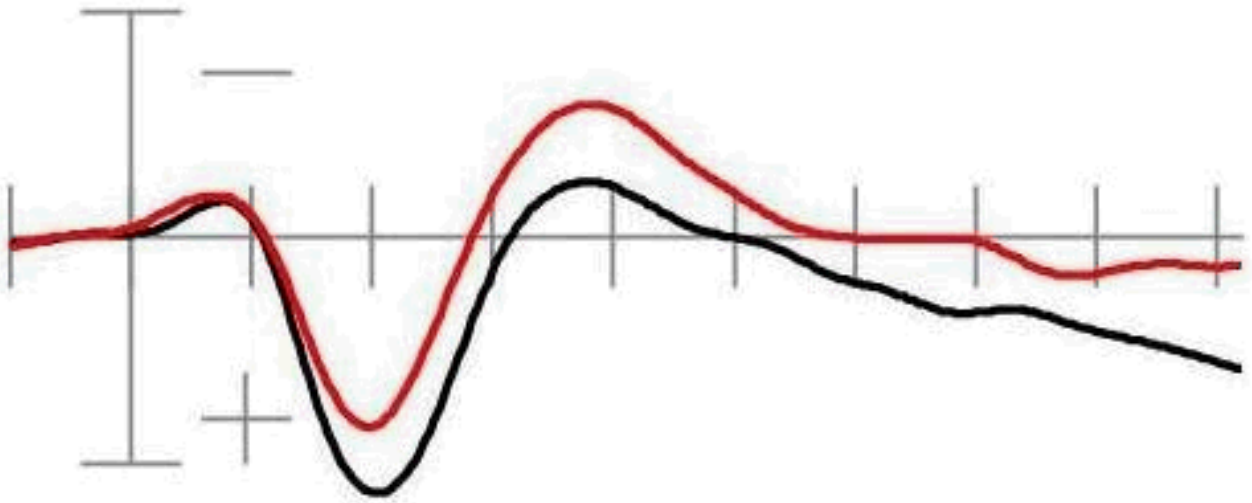
Dm Effects



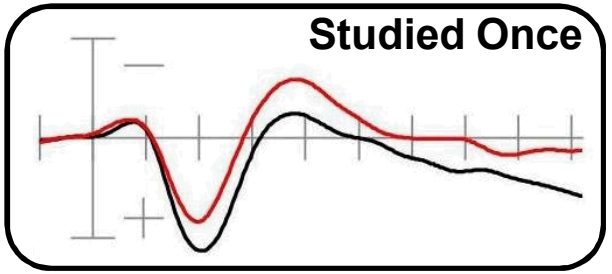
Dm Effects – Once Presented



Later Remembered

Later Forgotten

Dm Effects – First Presentations



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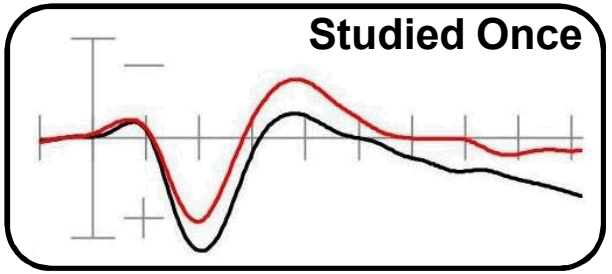
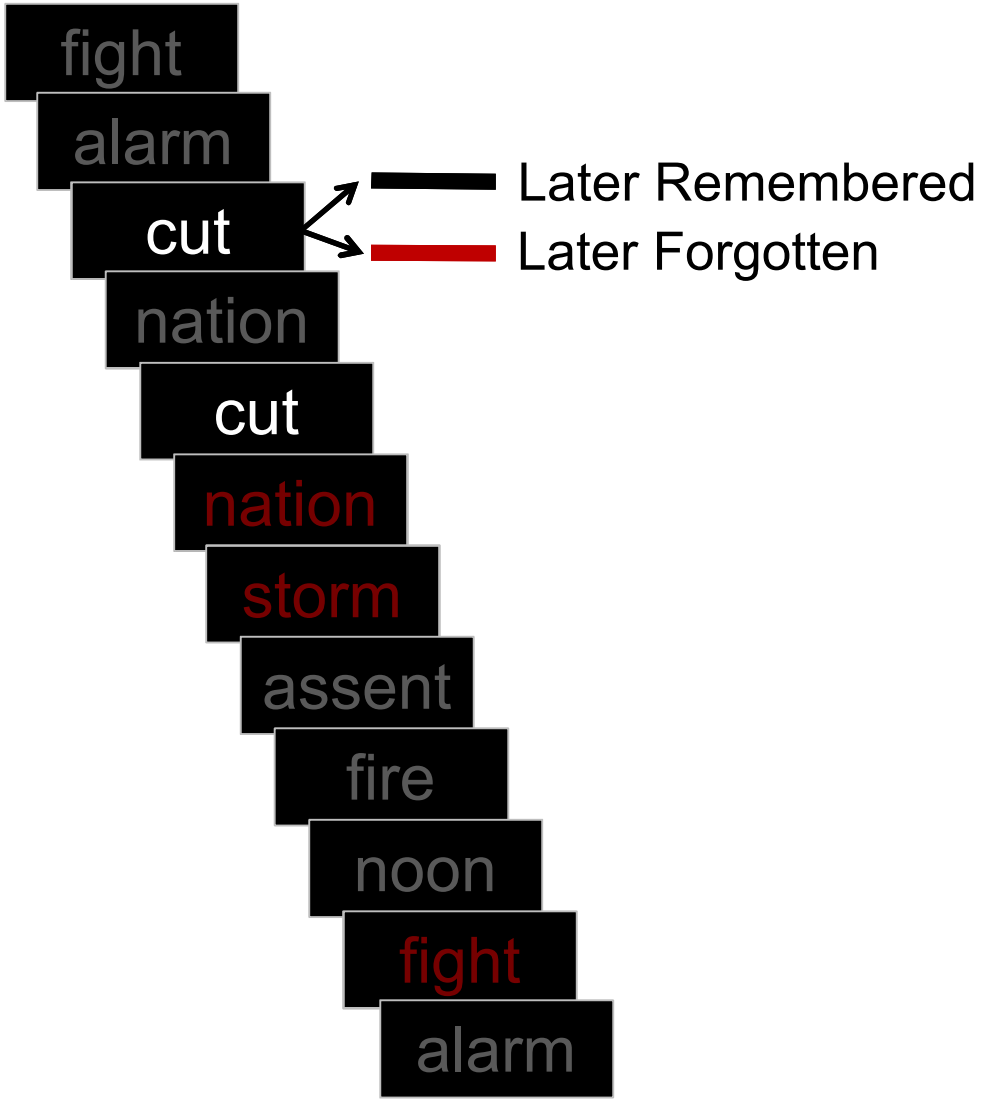
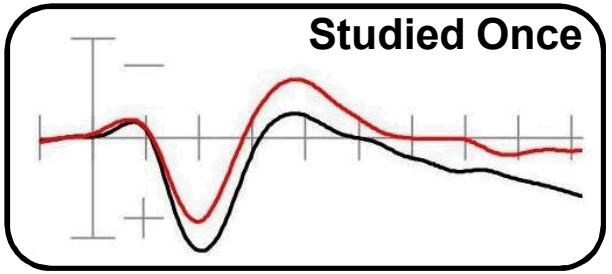
Dm Effects – First Presentations





Dm Effects – First Presentations



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Later Remembered
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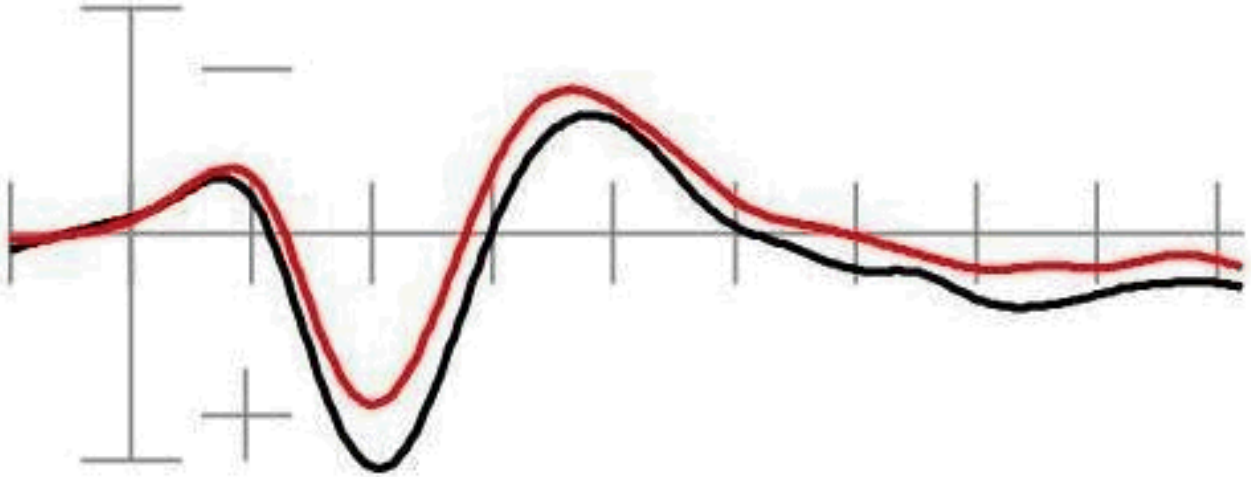

Dm Effects – First Presentations

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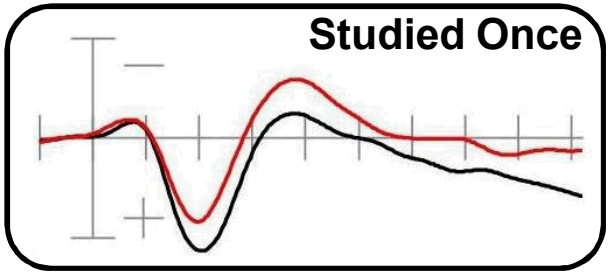

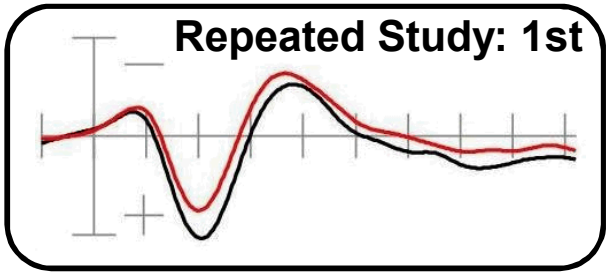

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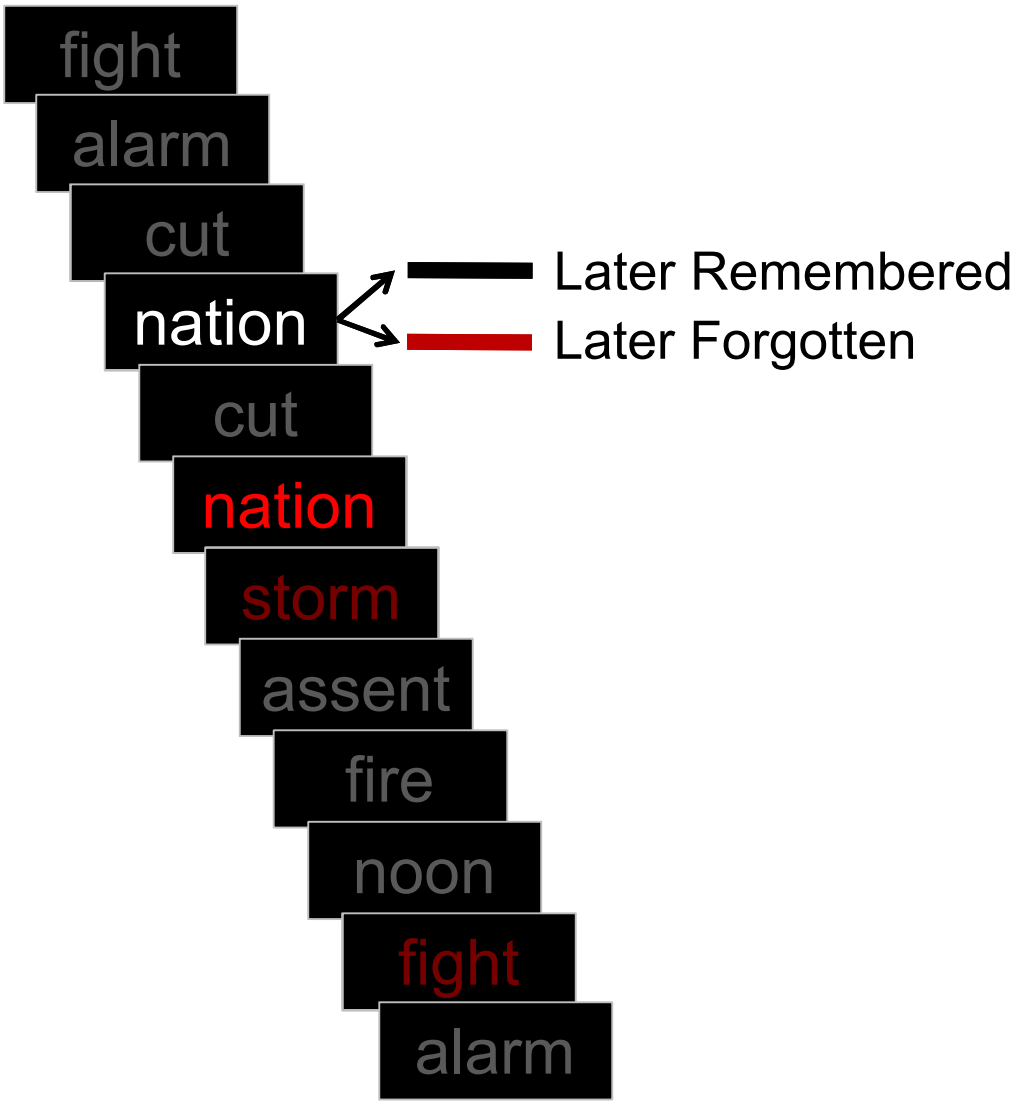
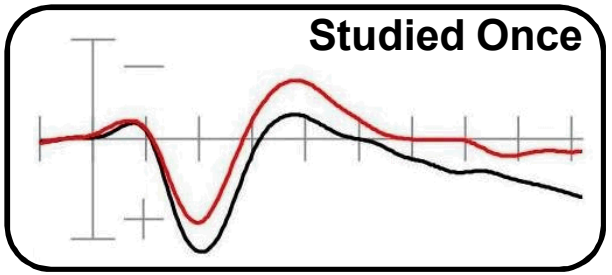
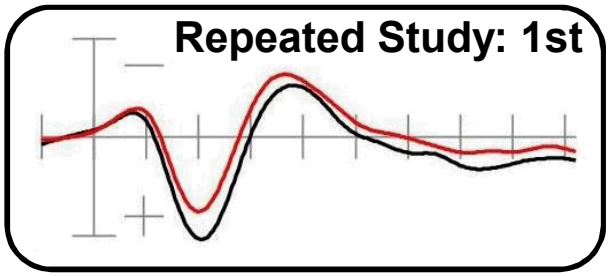
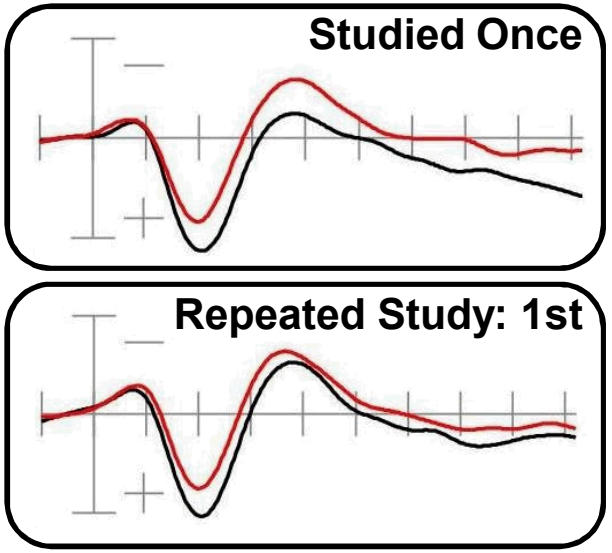






Dm Effects – First Presentations



fight
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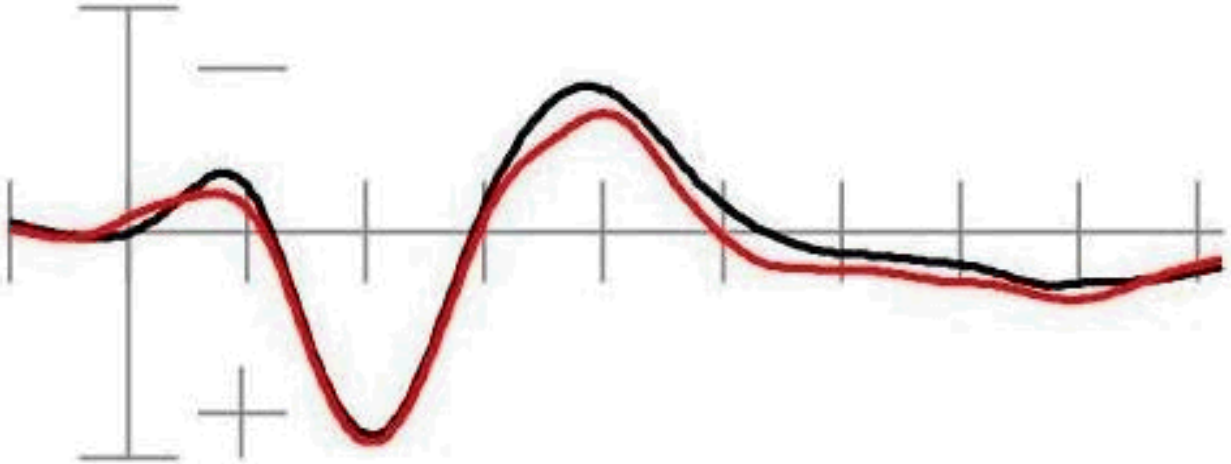
fire
noon
fight
alarm

Later Remembered
Later Forgotten



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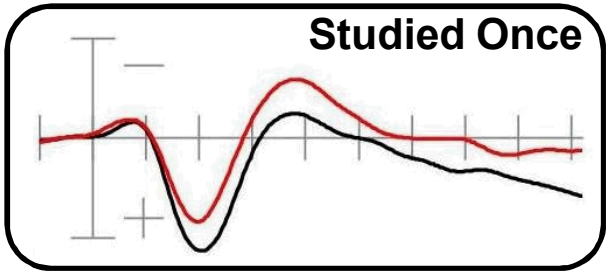
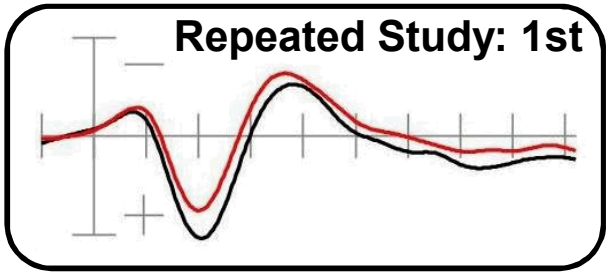
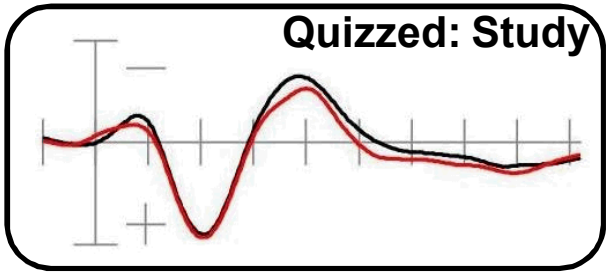
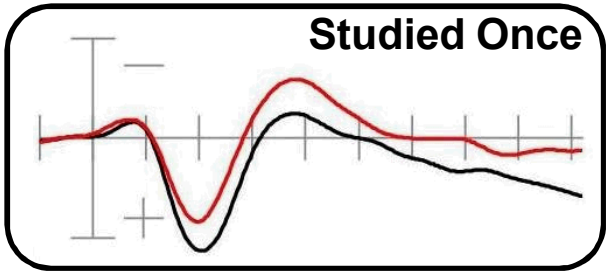






Dm Effects – Short Lag Repetitions



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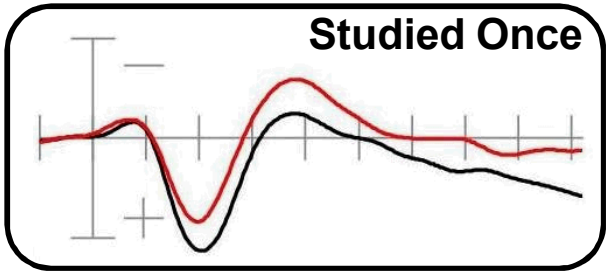

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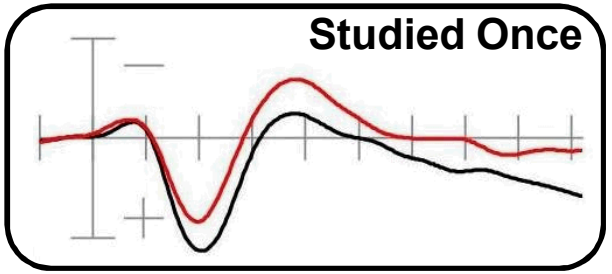

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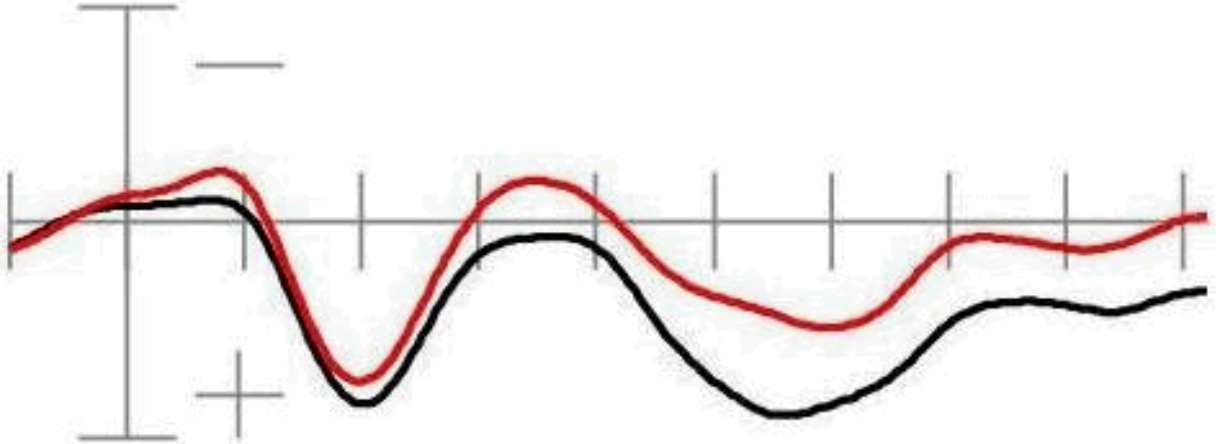

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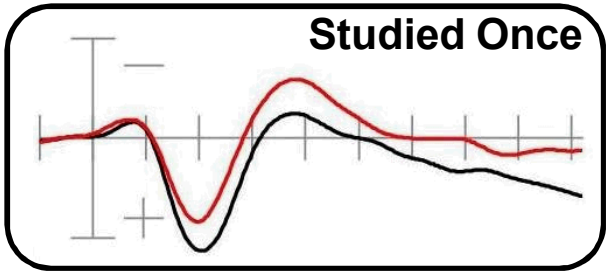

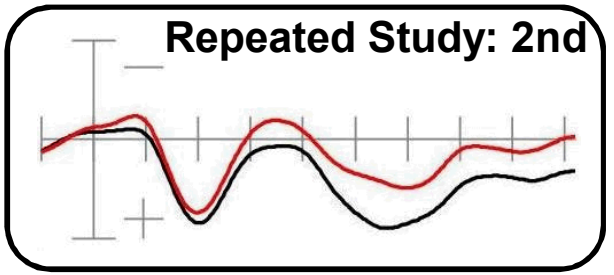

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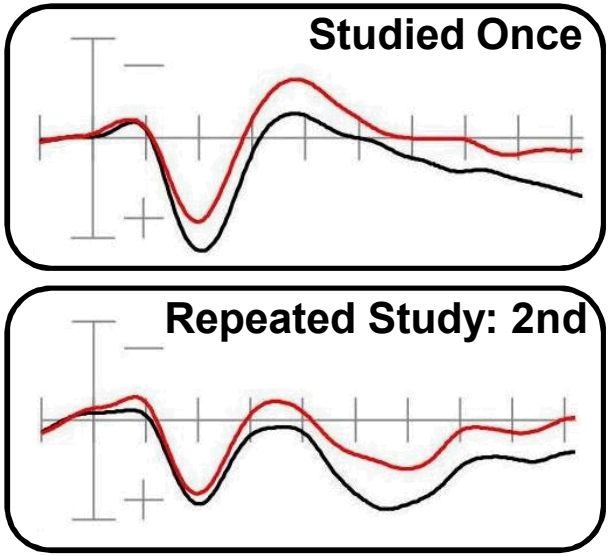

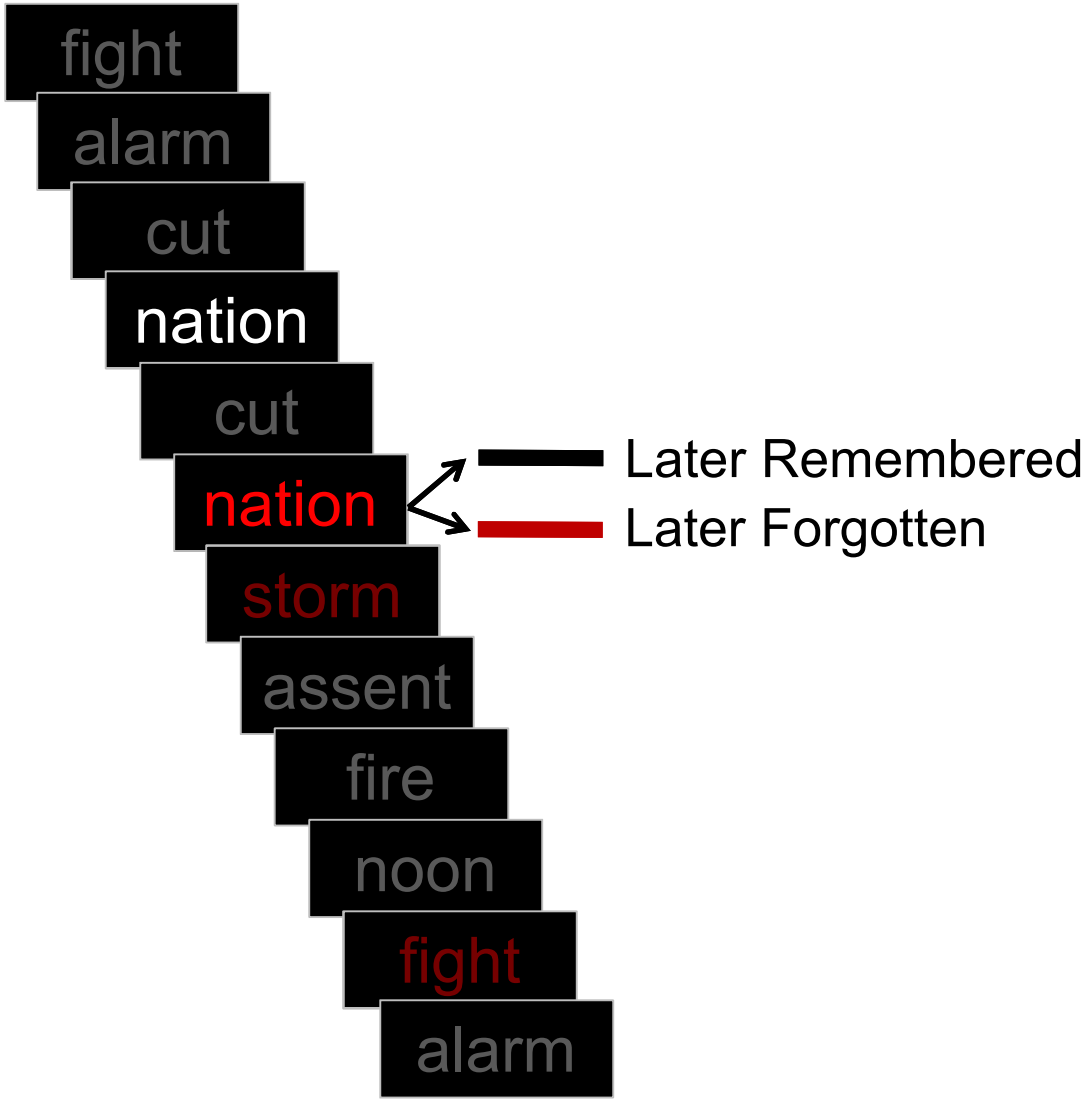

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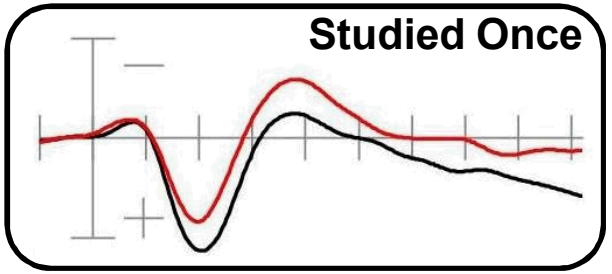

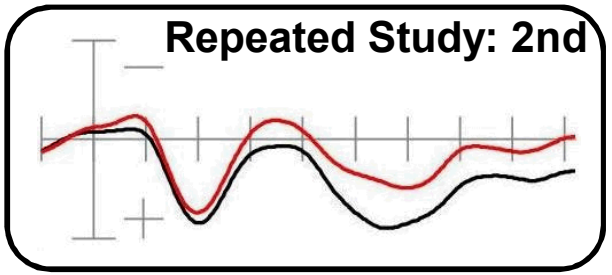

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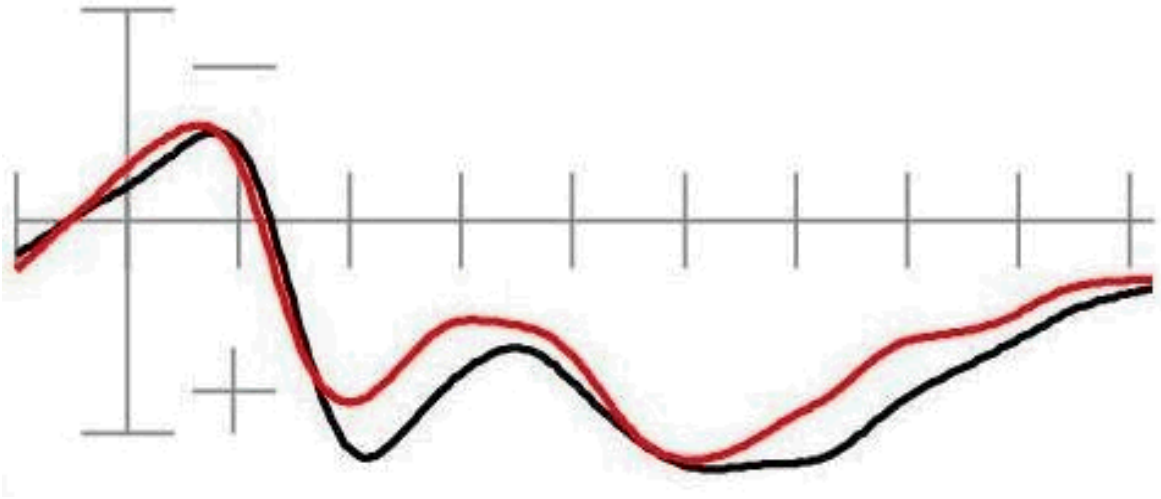

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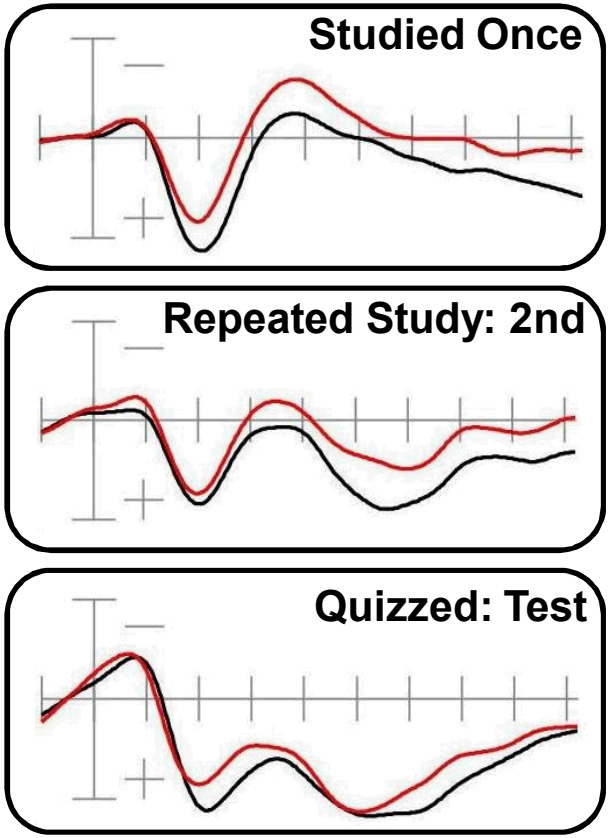
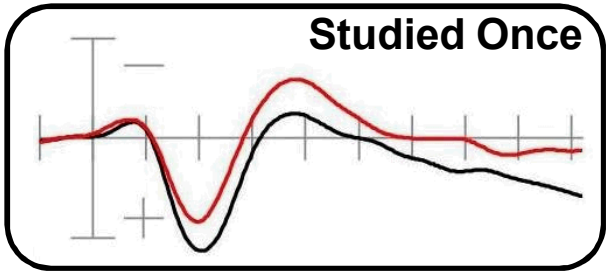


Dm Effects – Long Lag Repetitions



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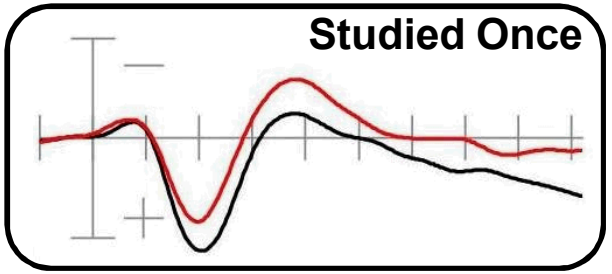
Dm Effects – Long Lag Repetitions



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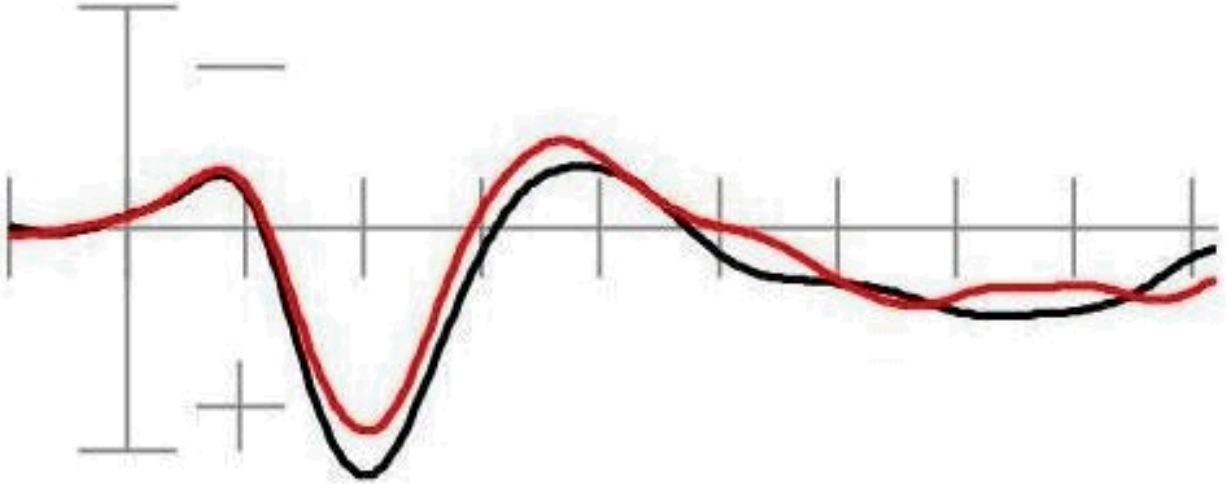

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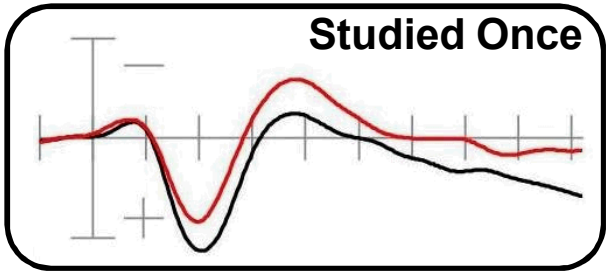

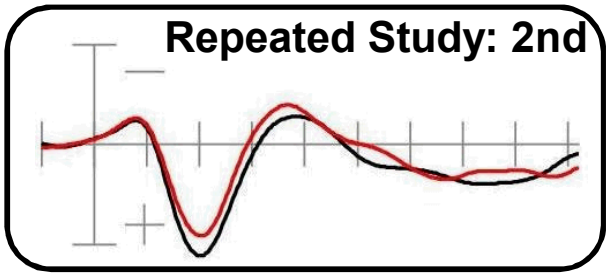

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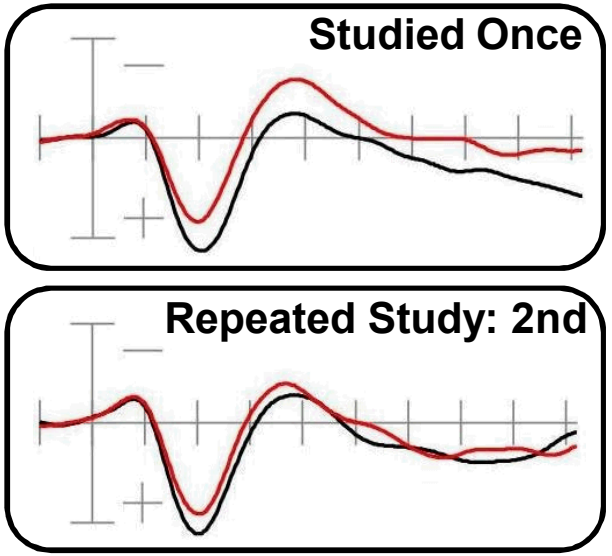

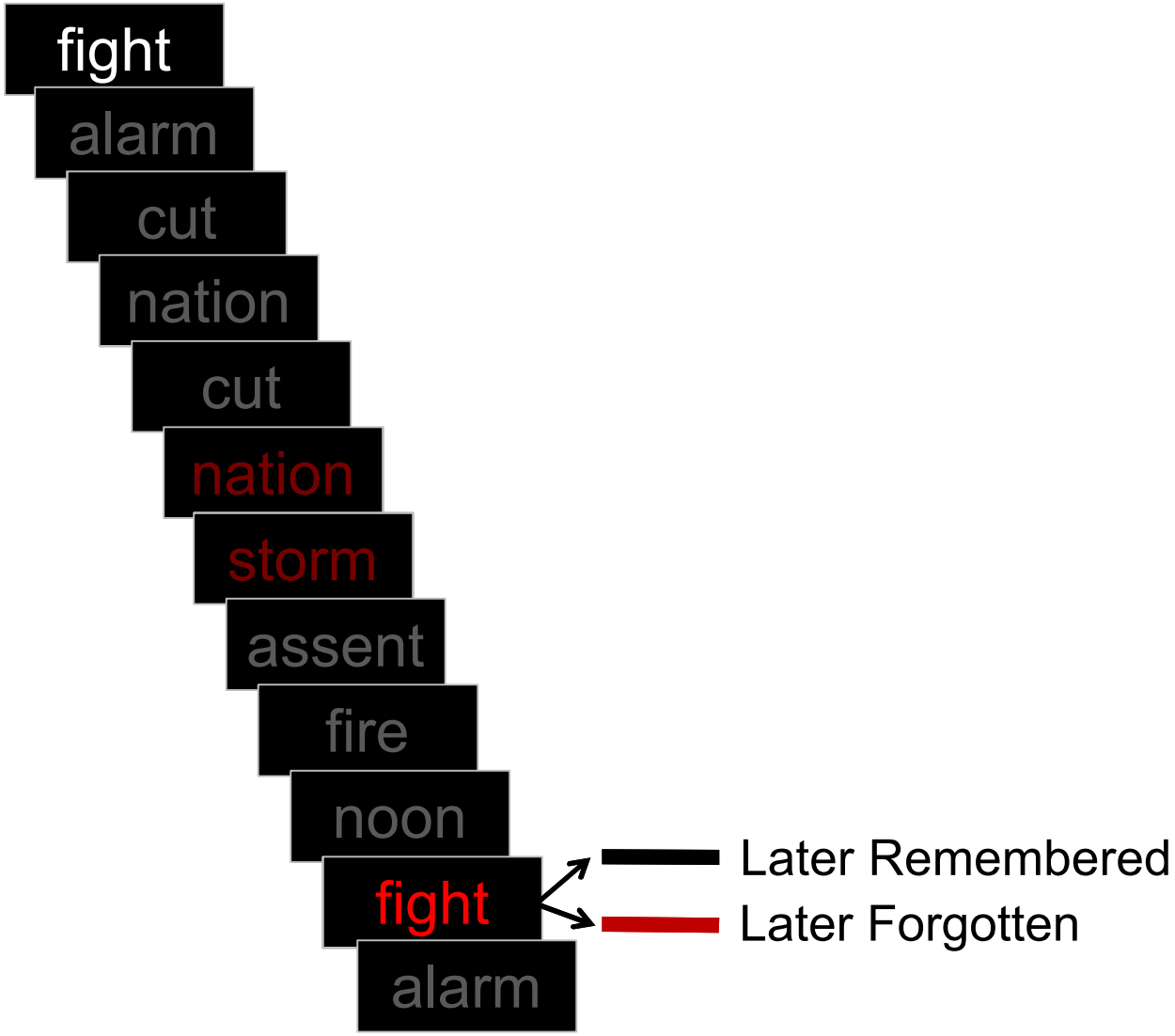

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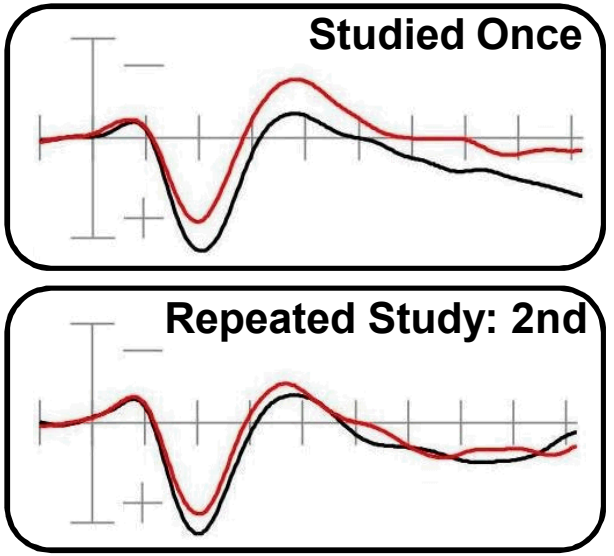

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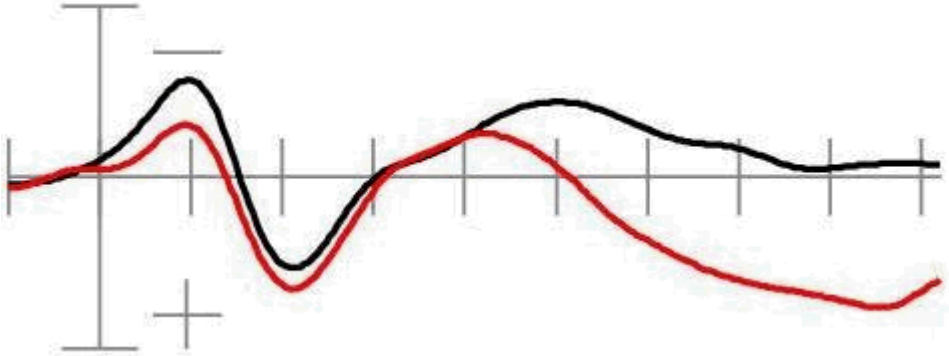

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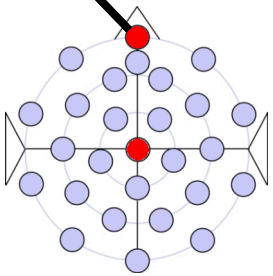

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Summary of Dm Effects

- Classic Dm Effect for once-presented words
- No Dm Effect for the first presentations of repeated words
  - More of those words would have been forgotten if not for additional presentations
  - Subsequent memory driven by second presentation of the words

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Summary of Dm Effects

- What about the items that were studied twice with a long lag between presentations?
  - No spacing effect
  - No LPC
  - No Dm Effect...
- Individual differences?

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Study Strategies

- Quizzing during study session benefited memory at test
- Could some participants have adopted a self-testing strategy for the words that were not quizzed?
- **Developed computational model to predict whether or not participants were using a self-testing strategy**
  - Compared behavioral performance and ERPs at study for participants classified as using passive study or self-testing strategies

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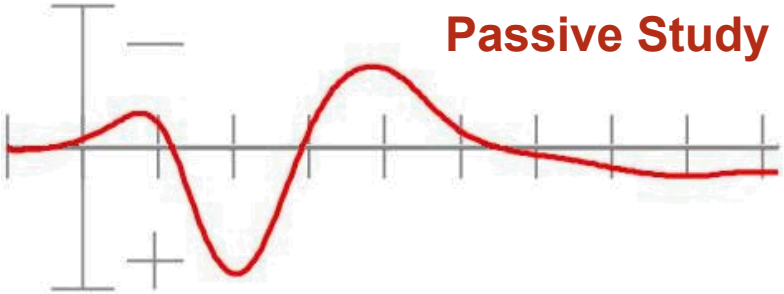
Model Example

Known Conditions

Unknown Condition

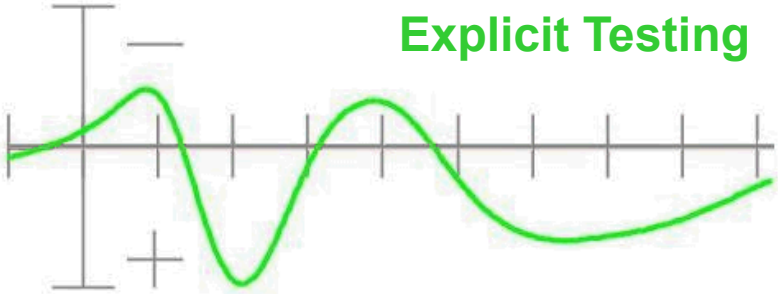
First presentation of studied words

Passive Study



Words quizzed after long lag

Explicit Testing



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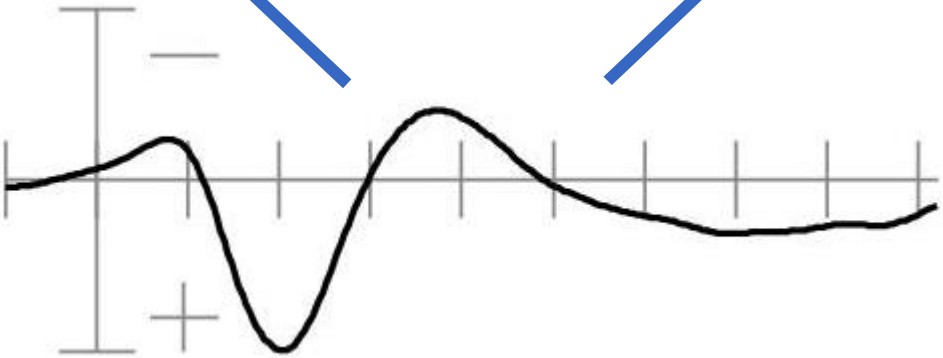

Words repeated after long lag

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Model Classification Results

- 18 of 23 participants classified as using passive study strategy
  - Average performance at test: 45% correct
- 5 participants classified as using a self-testing strategy
  - Average performance at test: 72% correct

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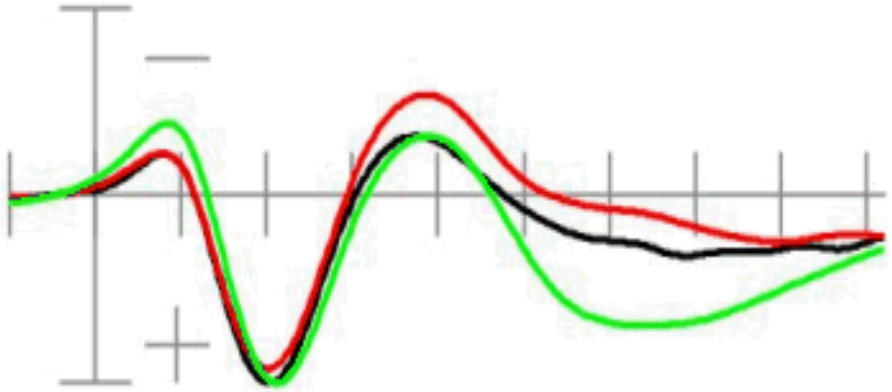
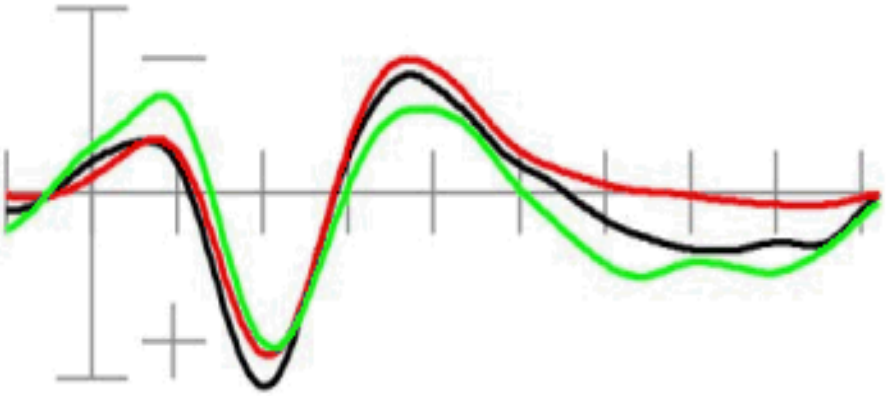
ERPs Sorted by Model Classification

"Passive Study" Group



"Self-testing" Group



First presentation of studied words

Words quizzed after long lag

Words repeated after long lag ← Unknown condition

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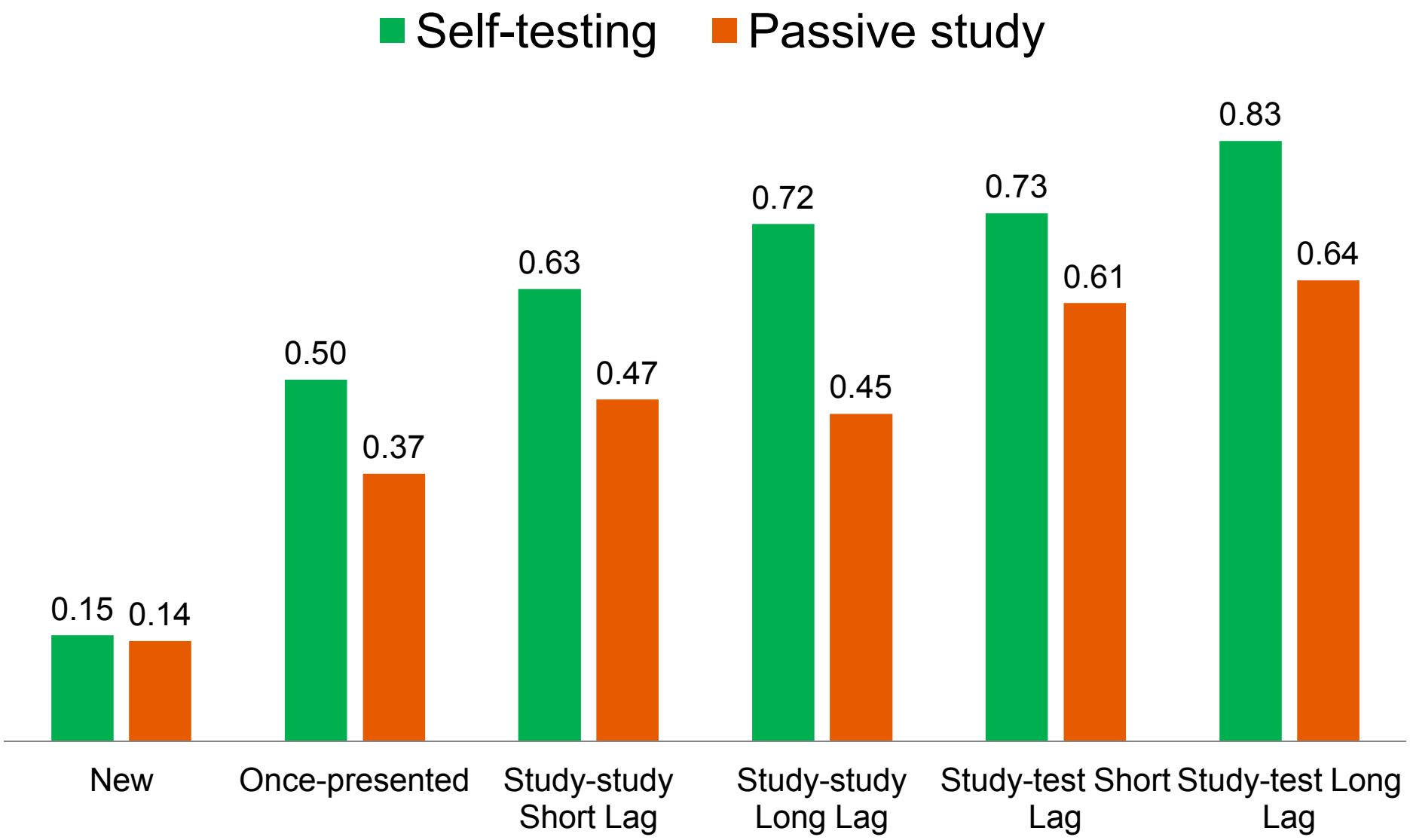
Spacing Effects