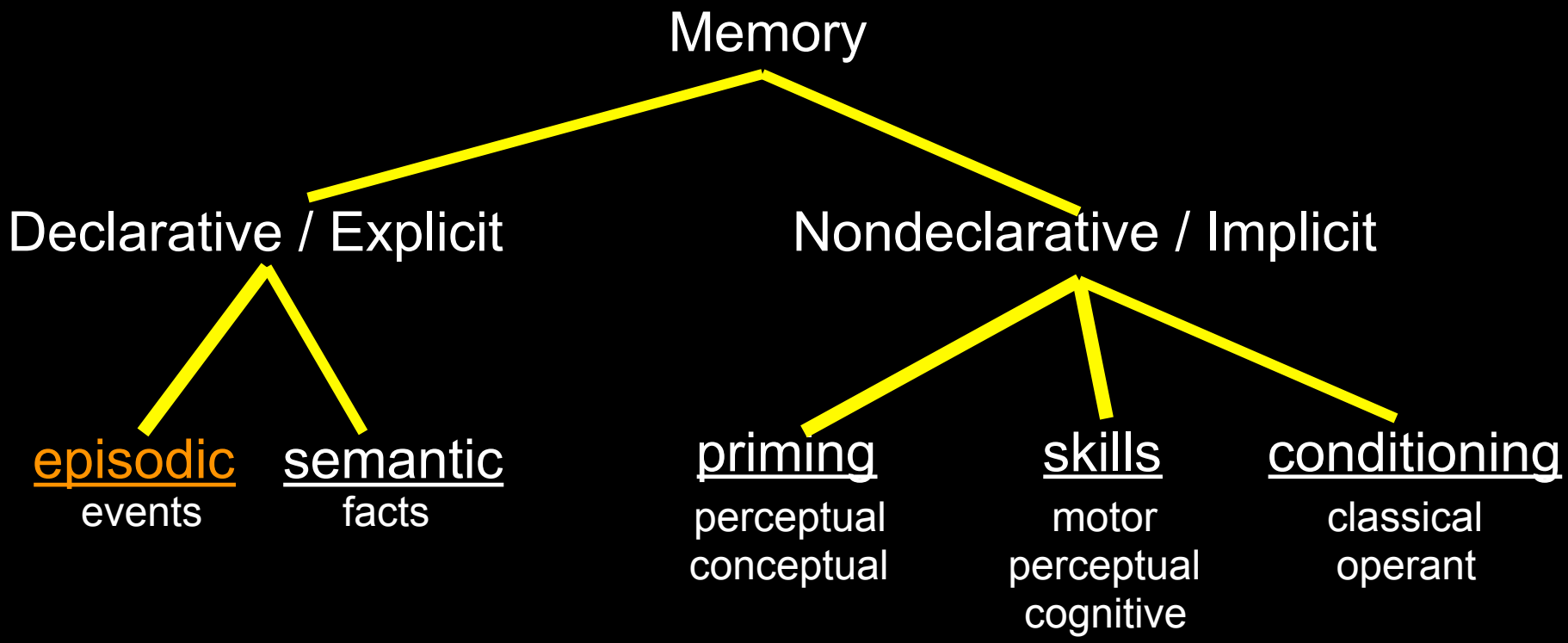
Episodic Encoding:
Building Memories of Life's Events

Outline

- What is Episodic Memory
- Measuring Episodic Memory
- Principles of Episodic Encoding
  - Attention
  - Levels of Processing
  - Retrieval Practice and Encoding
  - Repetition and Spacing

Multiple Long-Term Memory Systems



After Squire (1992)

Episodic vs. Semantic Memory

Episodic memory

conscious memory for a specific event (what) that occurred in a specific time (when) and place (where) – Tulving (1972)

What did you discuss the last time you were with friend X?

Where and when did you last see friend X?

Semantic memory

general knowledge about the world (e.g., facts and concepts); not tied to a specific learning event

What is a *smartphone*?

George Washington was the 1st President.

Stages of an Episodic Memory

Encoding

- Forming a memory representation

Consolidation

- Transforming the memory representation

Retrieval

- Bringing the representation back to mind

Episodic Encoding

Processes that yield a durable memory trace about the co-occurrence of a set of event features, such that details about an event (i.e., the event features) can be later brought back to mind (i.e., remembered)

- Cognitive mechanisms that impact encoding?
- Brain mechanisms that mediate encoding?

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Measuring Episodic Memory in the Lab

Recall

- Free recall
- Cued recall

Recognition

- Item recognition
- Associative recognition

Measuring Episodic Memory in the Lab

Recall

- Free recall
  - *Write down all the word pairs that you remember from the study list*
- Cued recall
  - *Fill in the blank based on your memory of the study list*

Journey – _____
Spoon – _____

Measuring Episodic Memory in the Lab

Item Recognition

– For the following list of words/items, decide if each word is old (on the study list) or new:

- Book
- Airplane
- Lime
- Flower
- Puppy

Associative Recognition

– For the following word pairs, decide if pairing is intact, recombined, or new

- Mushroom-Flag
- Bread-Robot
- Oven-Tree
- Shirt-Airplane
- Blanket-Taxi

Participation Prompt #1

Subjects were given a text passage to learn

Three study conditions

- SSSS: four study presentations
- SSST: three study presentations followed by one test
- STTT: one study presentation followed by three tests

Which study strategy will result in the best memory? Why?

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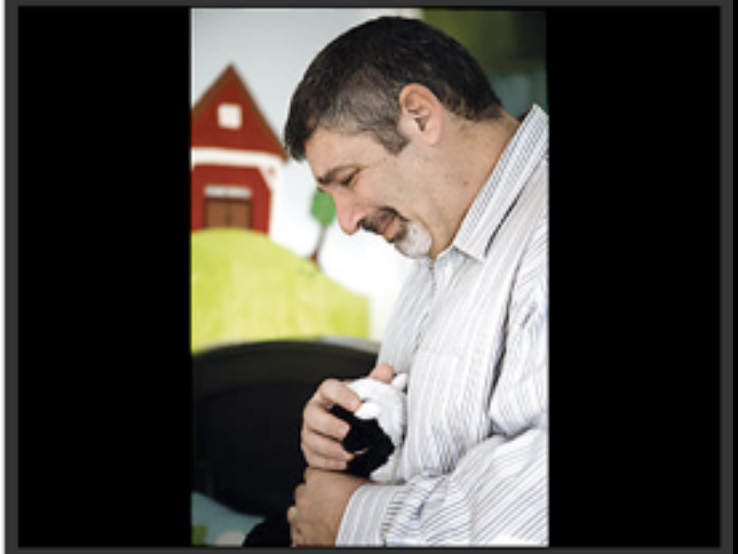
Fatal Distraction

Forgetting a child in the back seat of a hot, parked car is a horrifying, inexcusable mistake. But is it a crime?

By Gene Weingarten
Washington Post Staff Writer
Sunday, March 8, 2009; Page W08

SLIDESHOW Previous Next



Miles Harrison holds a toy that belonged to his son, Chase, who died after being left in the back seat of his father's car last summer.
(Rebecca Drobis - Copyright Rebecca Drobis)

The defendant was an immense man, well over 300 pounds, but in the gravity of his sorrow and shame he seemed larger still. He hunched forward in the sturdy wooden armchair that barely contained him, sobbing softly into tissue after tissue, a leg bouncing nervously under the table. In the first pew of spectators sat his wife, looking stricken, absently twisting her wedding band. The room was a sepulcher. Witnesses spoke softly of events so painful that many lost their composure. When a hospital emergency room nurse described how the defendant had behaved after the police first brought him in, she wept. He was virtually catatonic, she remembered, his eyes shut tight, rocking back and forth, locked away in some unfathomable private torment. He would not speak at all for the longest time, not until the nurse sank down beside him and held his hand. It was only then that the patient began to open up, and what he said was that he didn't want any sedation, that he didn't deserve a respite from pain, that he wanted to feel it all, and then to die.

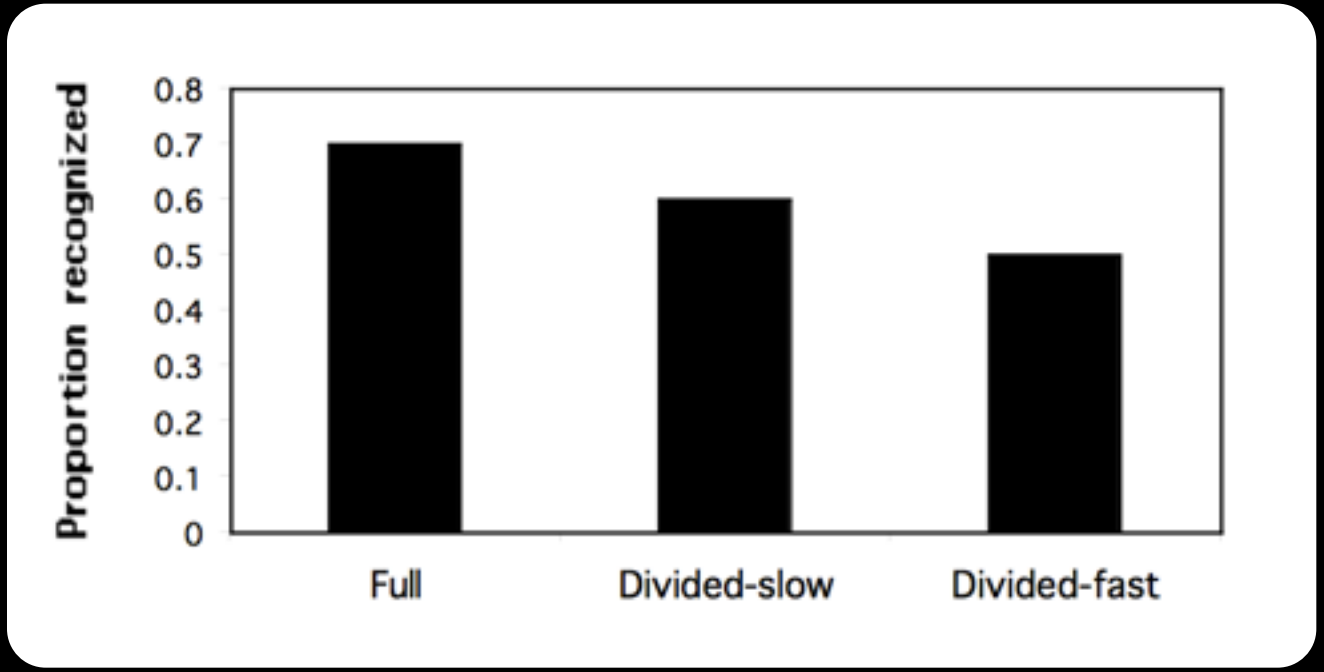
AUDIO: After the Tragedy: Todd Costello of Medina, Ohio, with wife Melody and daughters Kasey, 5, and Emily, 10, lost his son, Tyler, in 2002 after forgetting the 9-month-old in the back of his car in his office parking lot. He's had to find a way to live with the guilt. "On that morning," he says, "I had to make brief trips

Attention & Episodic Encoding

- **What happens when our attention is divided during encoding?**

Full-attention: intentional learning of visually presented words

Divided-attention: word learning plus a secondary task
- monitor auditory tones (indicate “high”, “medium”, or “low” pitch)
- rate of tone presentation was “slow” or “fast”



(Gardiner & Parkin, 1990)

Attention

"Attention… is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others."

William James, 1893

The “Spotlight” of Attention

M. C. Escher, Balcony, 1945

Selective Attention

- How do we choose to select one stream of information over another?
- Dual attention theory
  - **Top-down** (endogenous): goal-directed shift of attention
  - **Bottom-up** (exogenous): reflexive shift of attention triggered by salient or unexpected stimuli

Dual-Attention Theory

Posner's Task (1980)

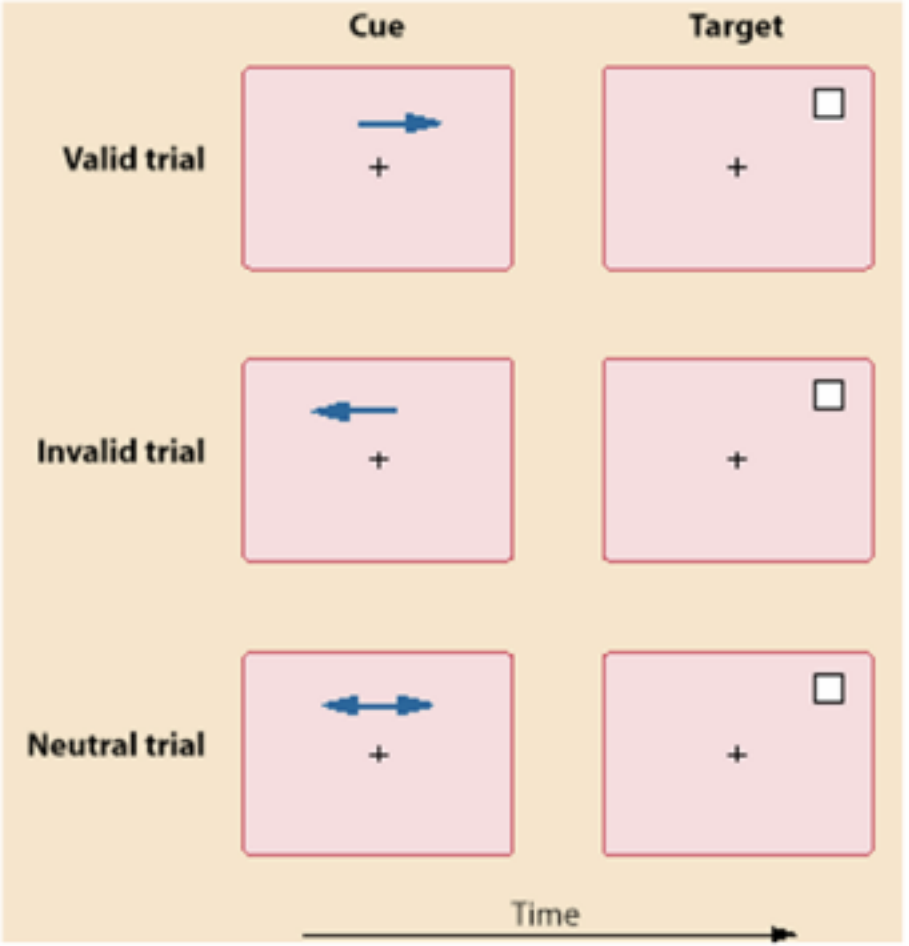
- focus visual attention to an area by using a cue

- measure reaction time to detect target when :

i) observer doesn't know where item will appear (neutral cue)

ii) observer is cued to where item will appear (valid cue)

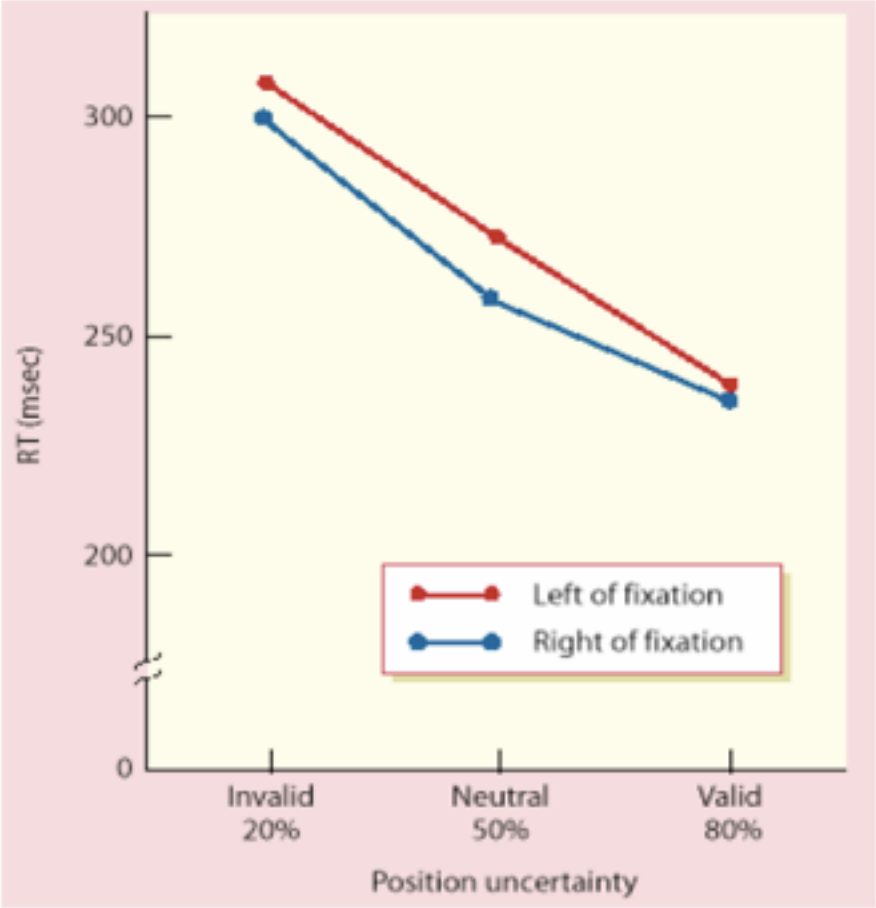
iii) observer is wrongly cued (invalid cue)



Dual-Attention Theory

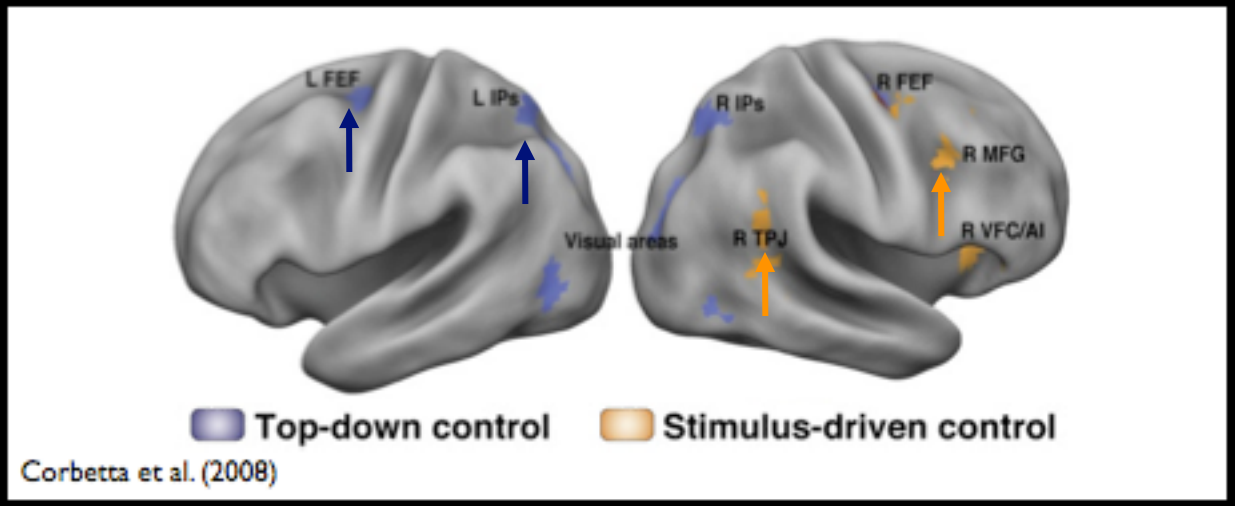
Posner's Task (1980)

- Detection is faster for valid targets
- Detection is slower for invalid cues



Posner, Nissen, & Ogden (1978)

Dual-Attention Theory



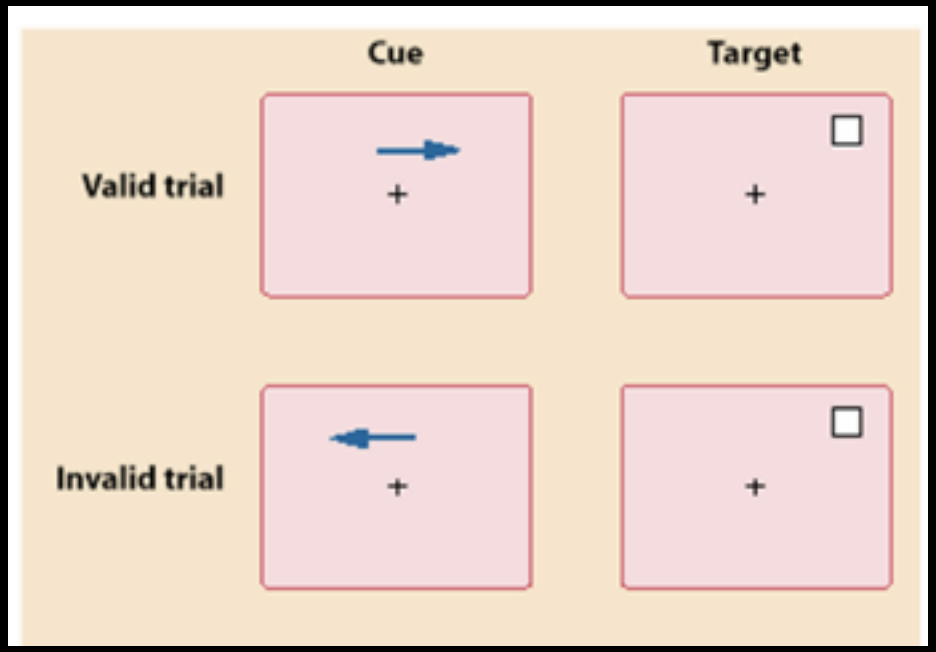
Two frontal-parietal networks

Top-down attentional control

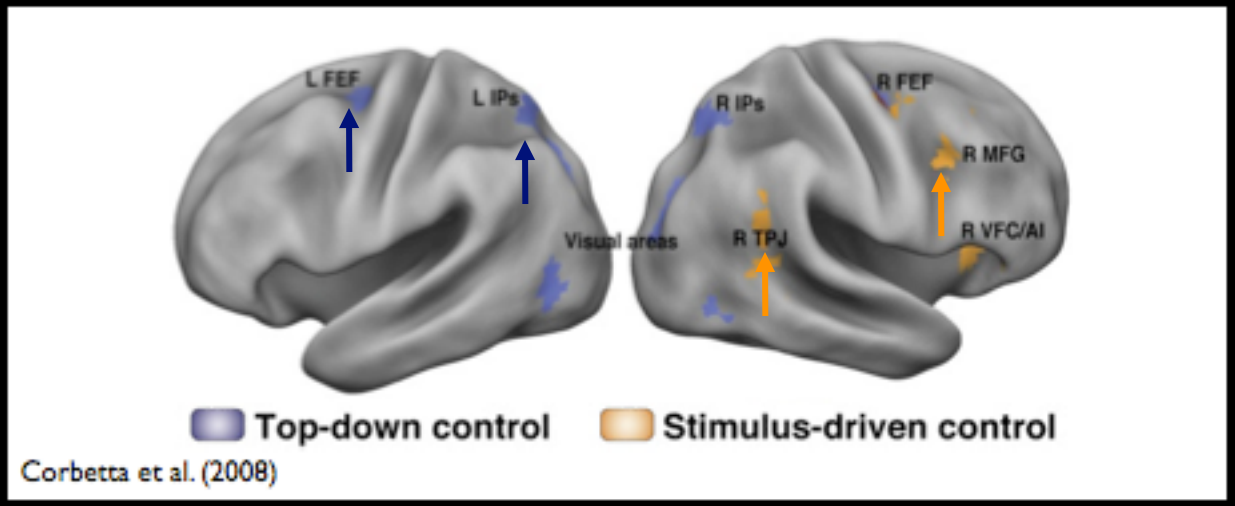
- Goal-directed (endogenous) shift of attention

Stimulus-driven attentional control

- Reflexive shift or capture of attention by salient or unexpected external stimuli (exogenous)



Dual-Attention Theory



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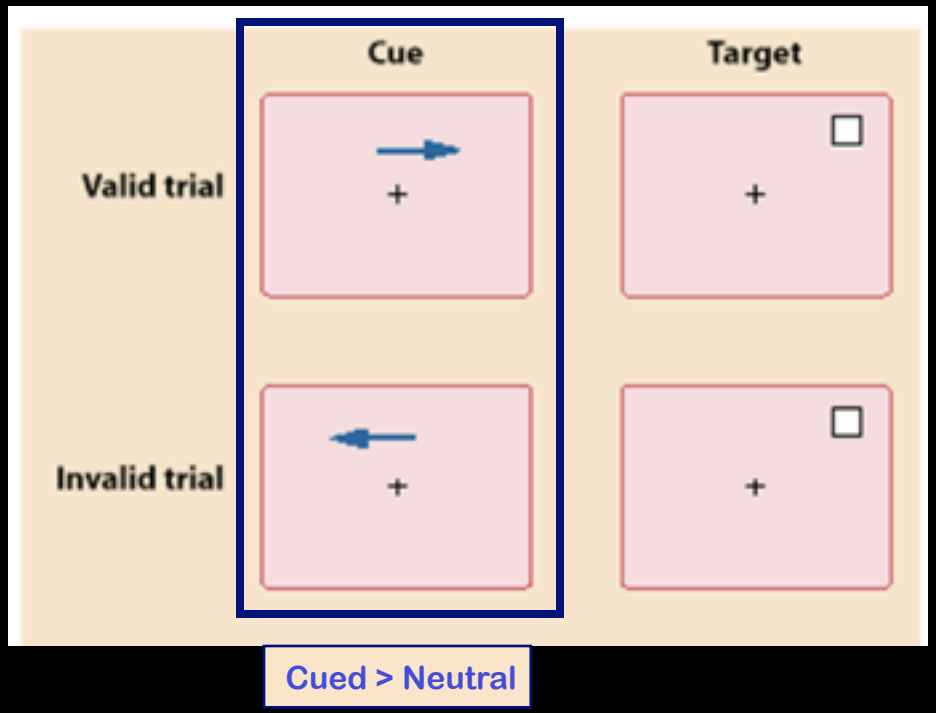

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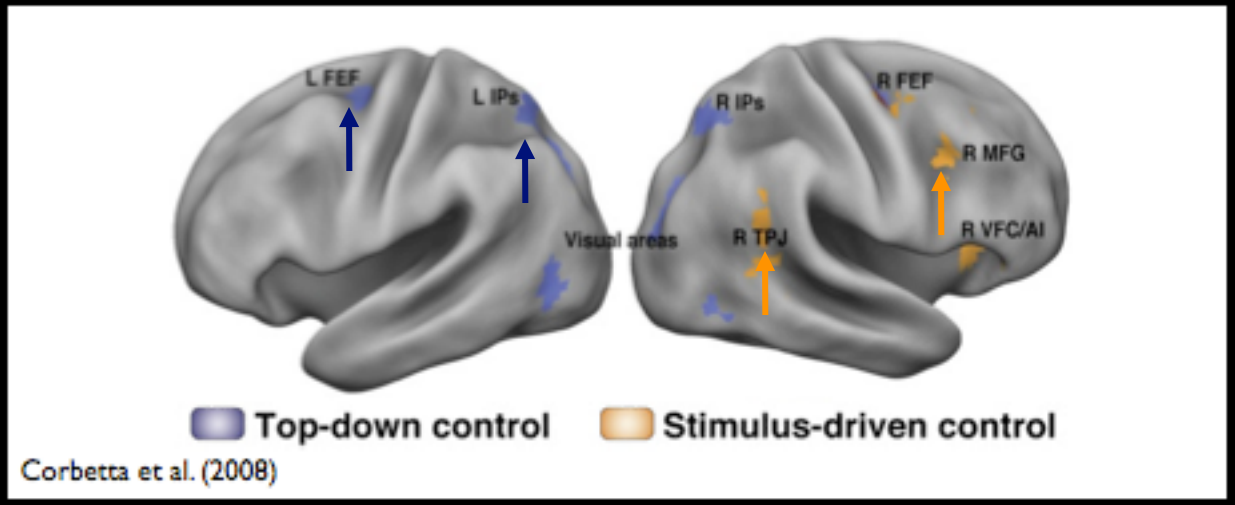

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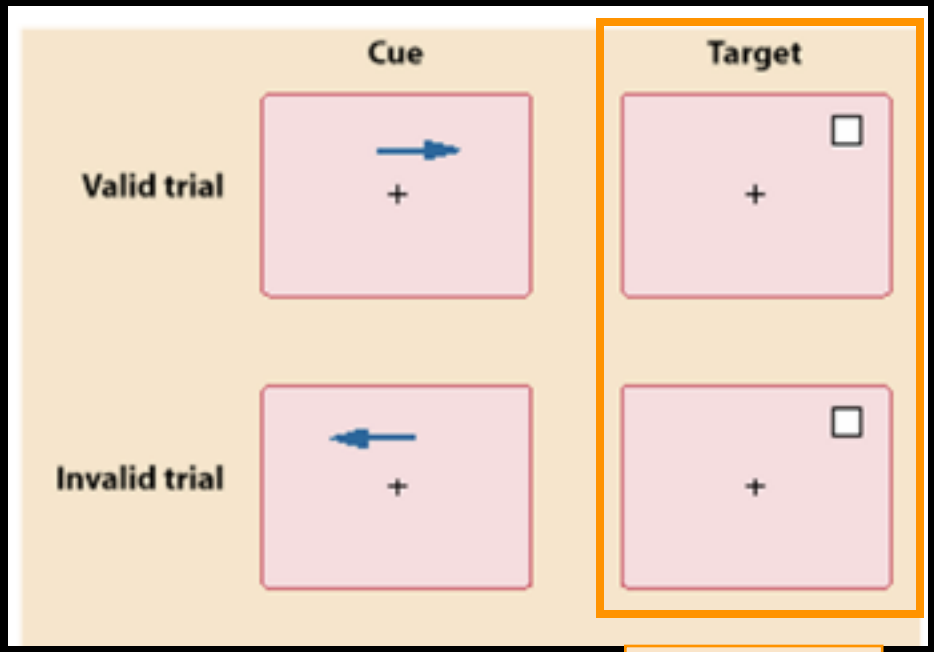
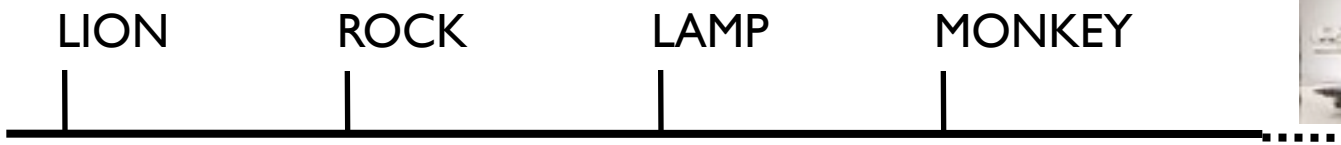


fMRI Correlates of Episodic Encoding

Study Items:



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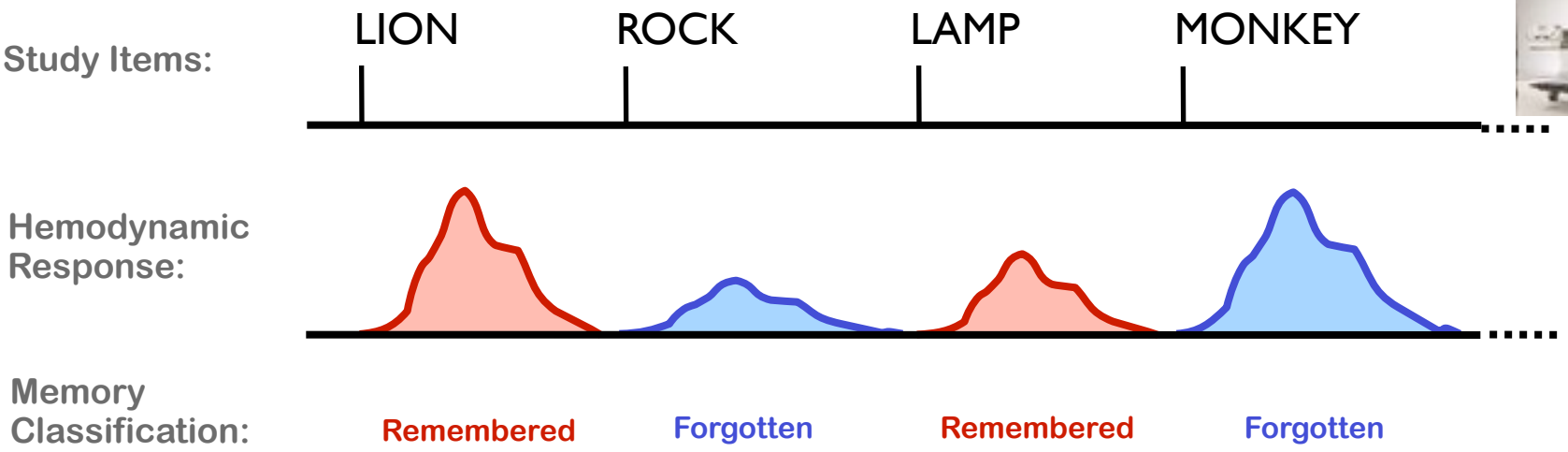


fMRI Correlates of Episodic Encoding

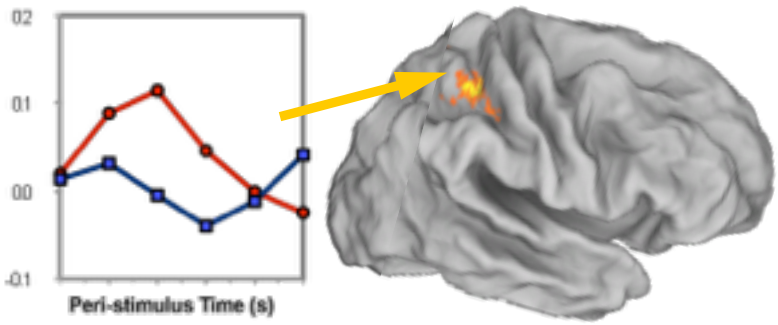
Study Items: LION ROCK LAMP MONKEY

Hemodynamic Response:

Memory Classification: Remembered Forgotten Remembered Forgotten

Encoding-Related Activity:

Positive Subsequent Memory Effect



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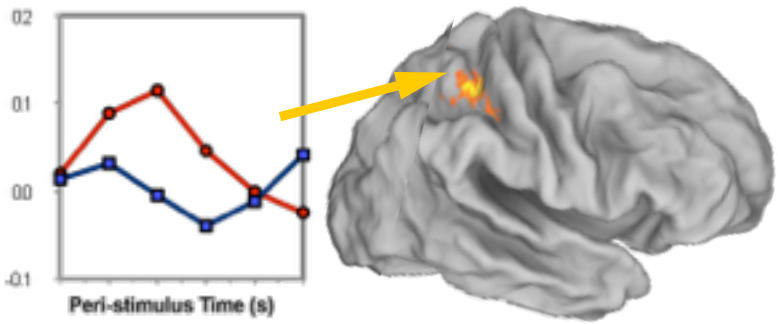
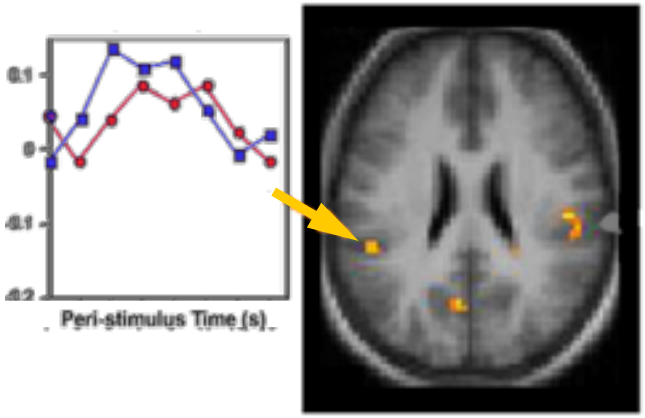
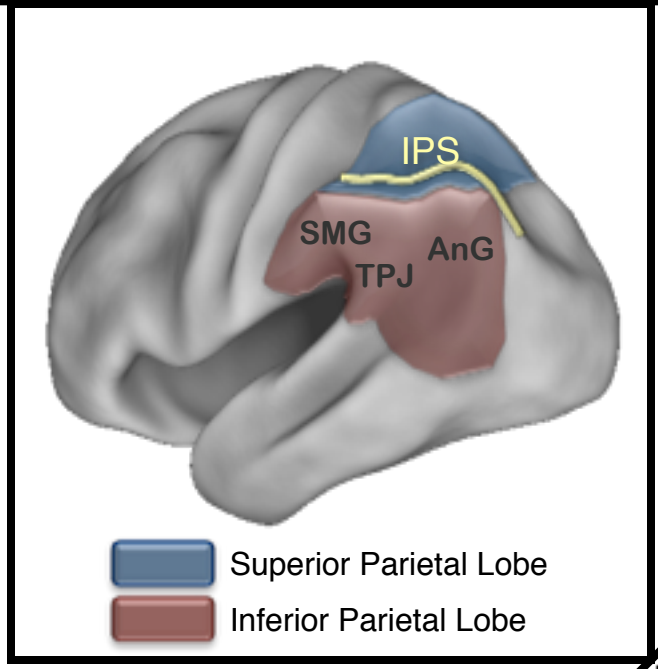
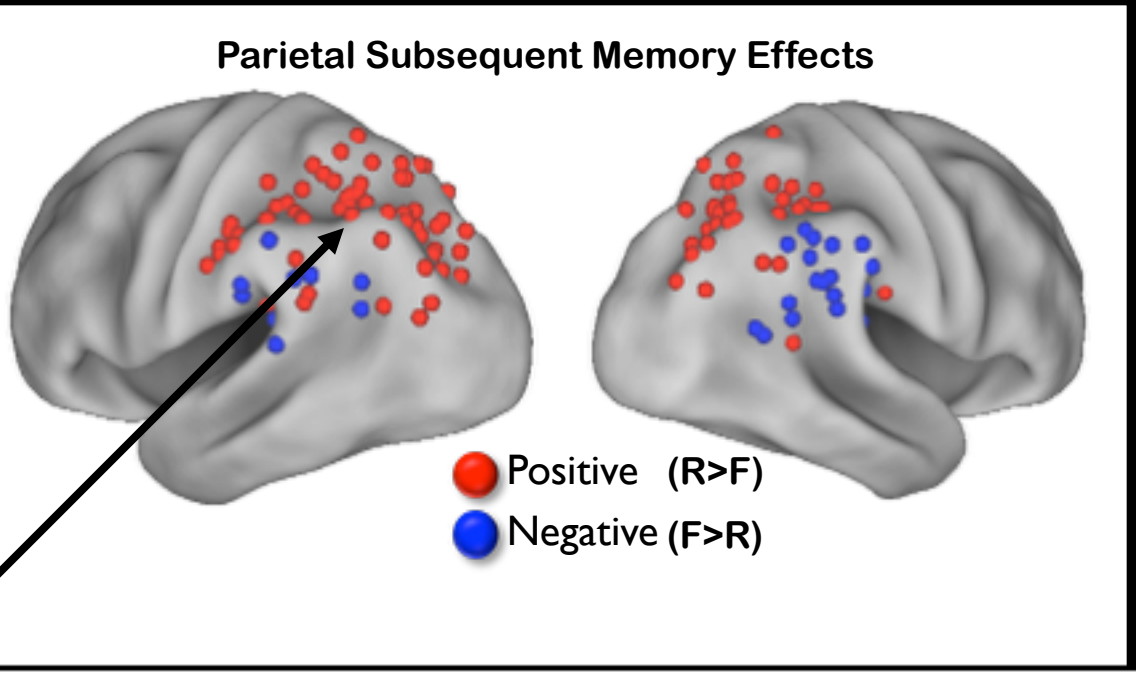


Negative Subsequent Memory Effect

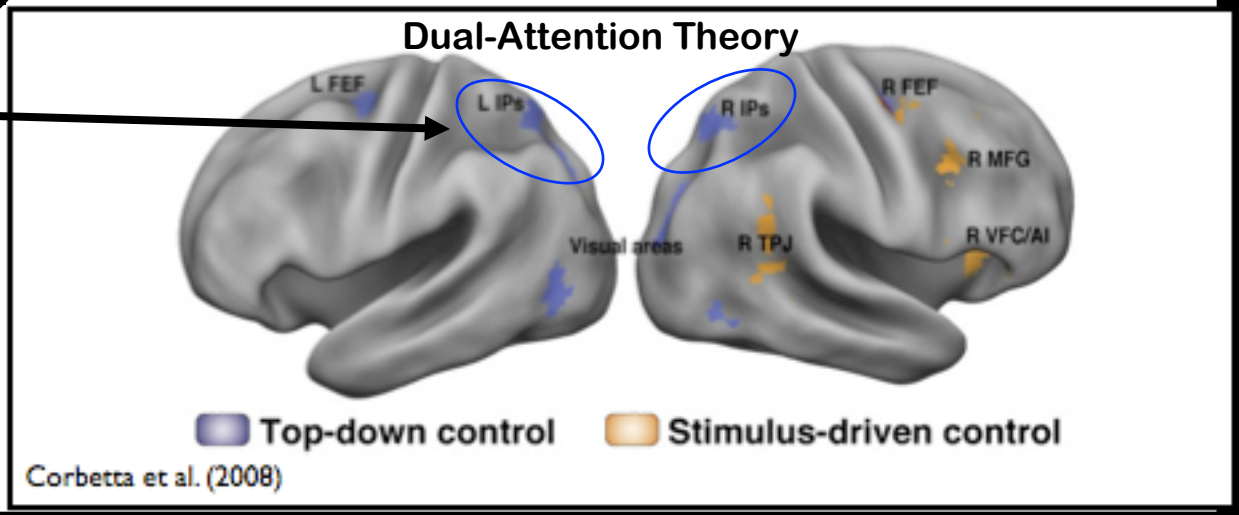


Parietal Correlates of Episodic Encoding





Top-down attention fosters encoding



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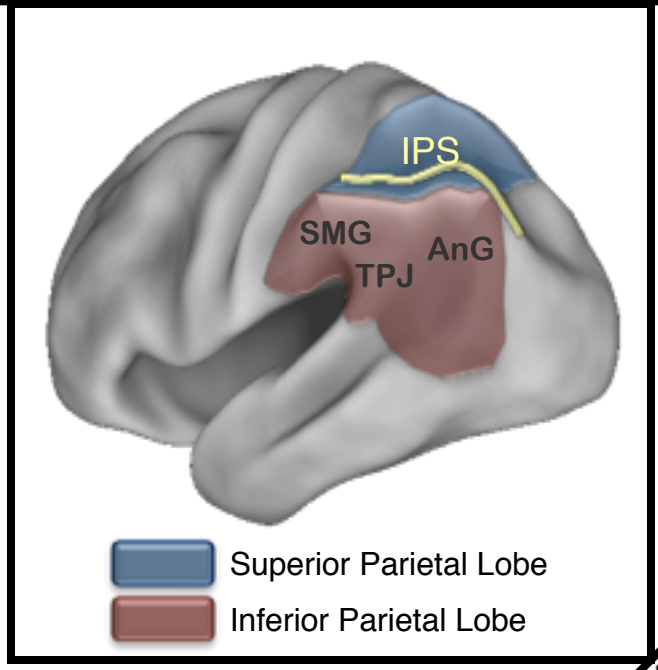
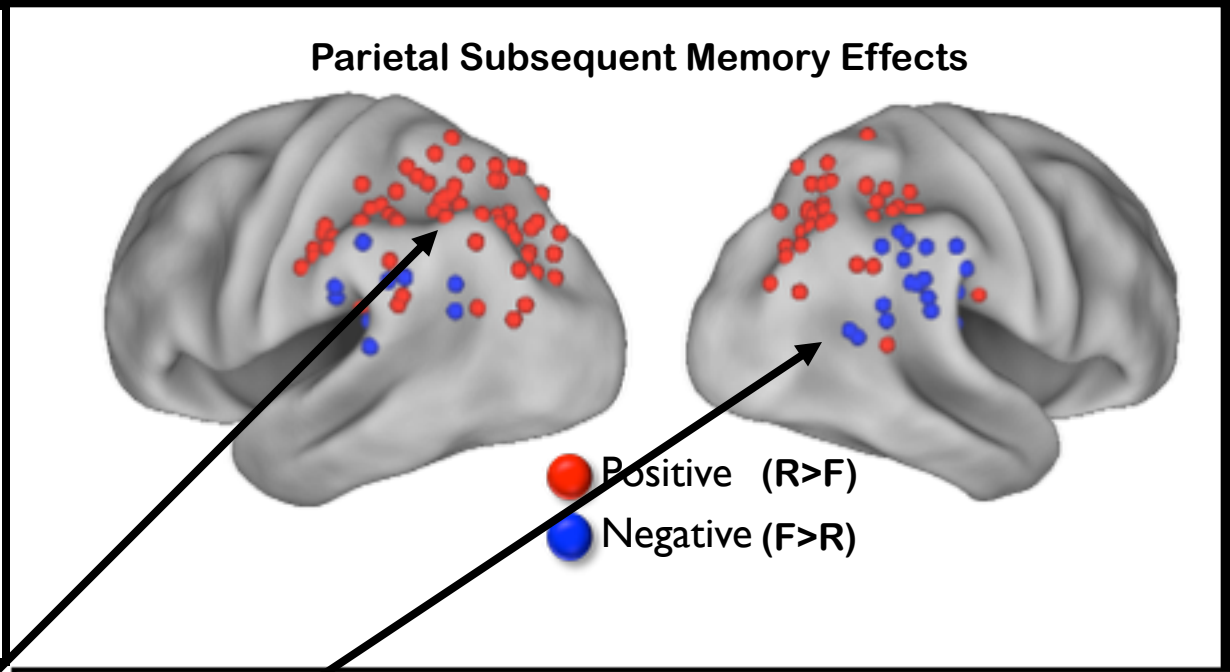
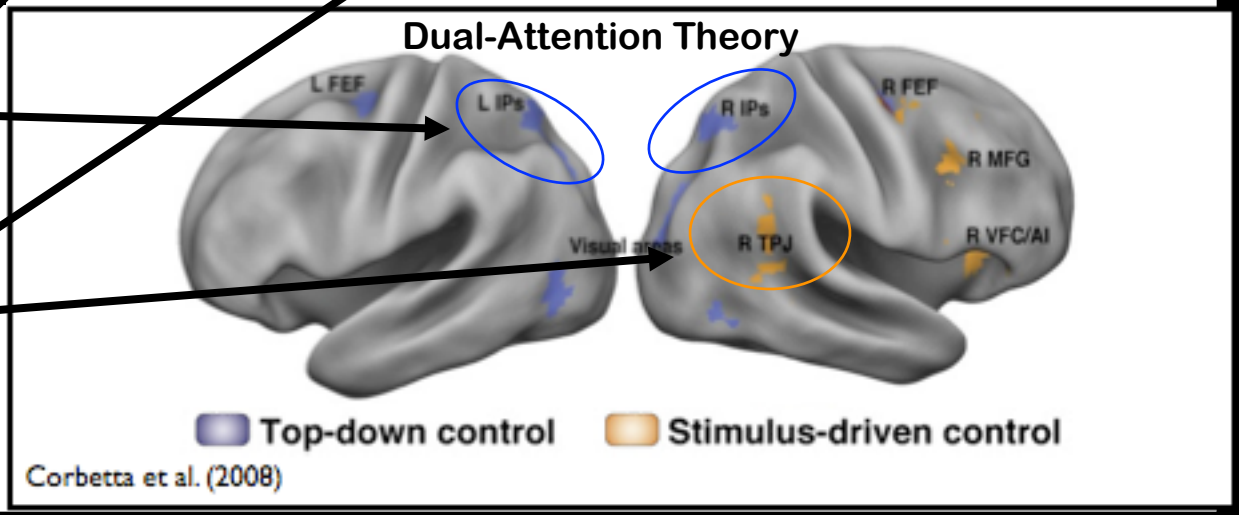




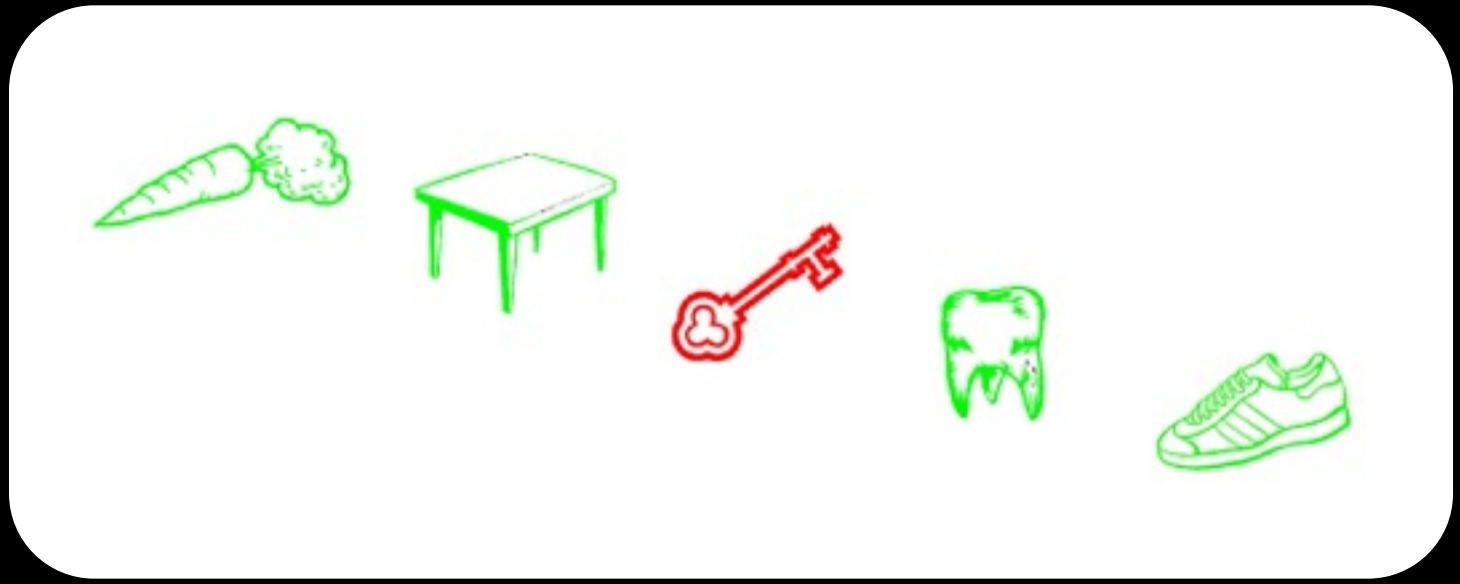
Top-down attention fosters encoding

Stimulus-driven attention can hinder encoding (if captured by irrelevant stimuli)



Distinctiveness, Attention, & Memory

- Isolation effect (aka Von Restorff effect)
  - Items or events that are distinctive (isolated) are better remembered than typical items or events



  - Due in part to distinctive items reflexively grabbing your attention (bottom-up)

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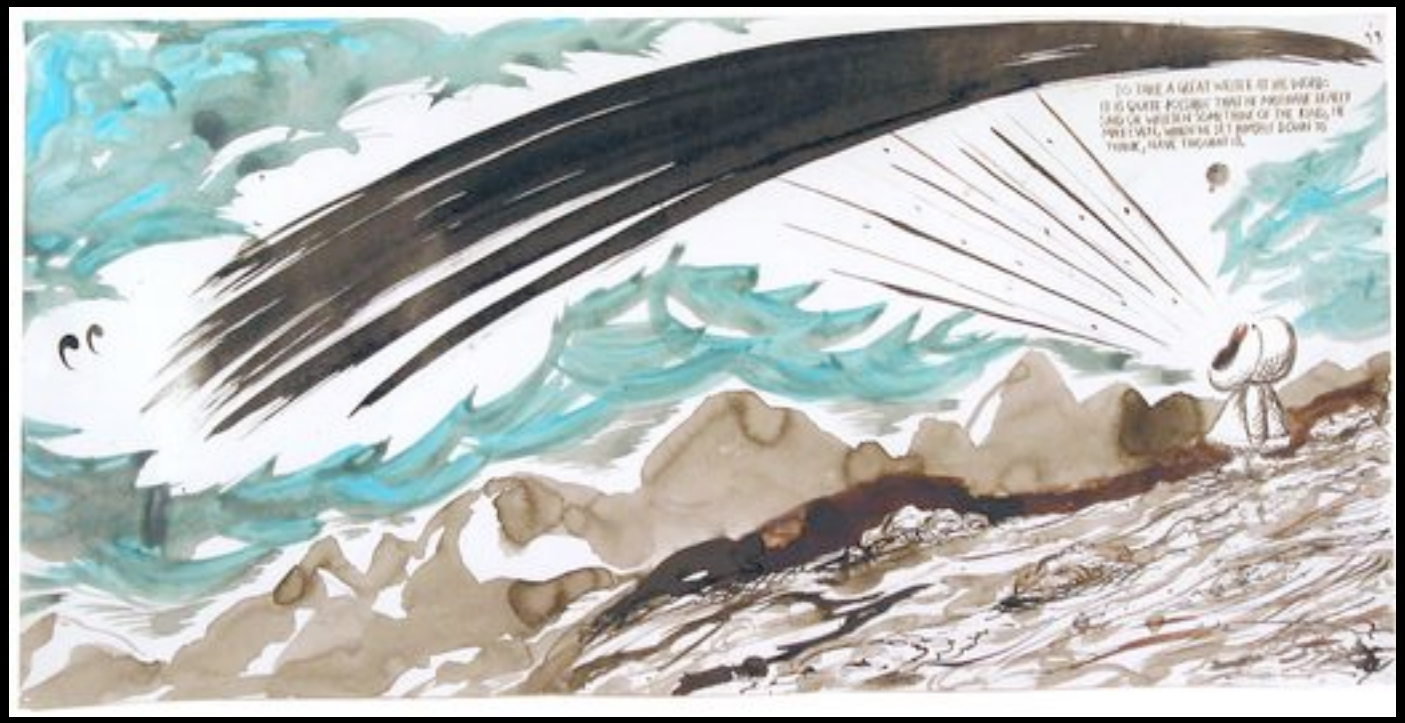
Depth of Processing

(Craik & Lockhart, 1972; Craik & Tulving, 1975)

Stimuli / Events can be processed at different “levels”



Depth of Processing

(Craik & Lockhart, 1972; Craik & Tulving, 1975)

Stimuli / Events can be processed at different “levels”

Shallow (sensory aspects)

perceptual: perceptual features of the presented stimulus
phonological: process / code stimulus via speech codes
semantic: evaluate the meaning of the stimulus

Deep (conceptual aspects)

Depth of Processing

(Craik & Lockhart, 1972; Craik & Tulving, 1975)

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Deep (conceptual aspects)

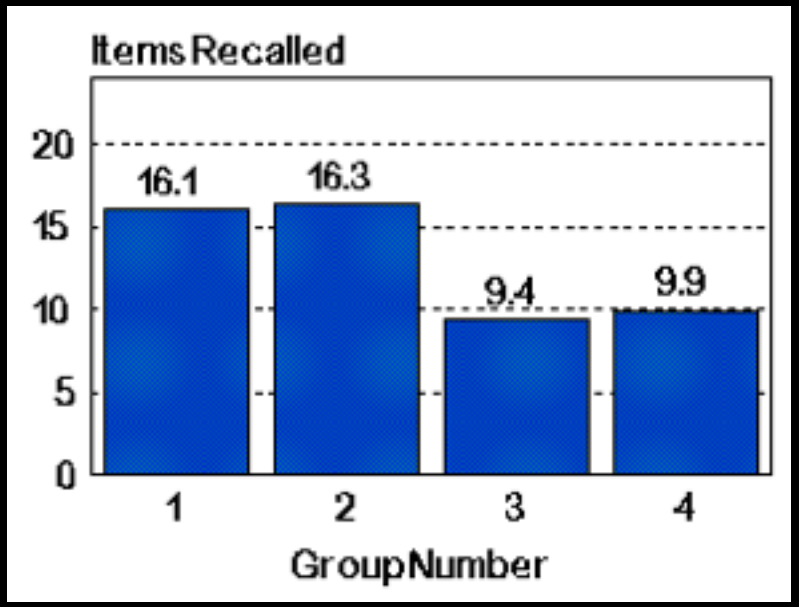
- “Deeper” processing = more effective encoding
- Challenges the “Modal Model” (time in WM=>LTM)

Encoding = incidental byproduct of active stimulus processing

DoP Effect: Hyde & Jenkins (1968)

Subjects performed one of four tasks with a list of 24 words

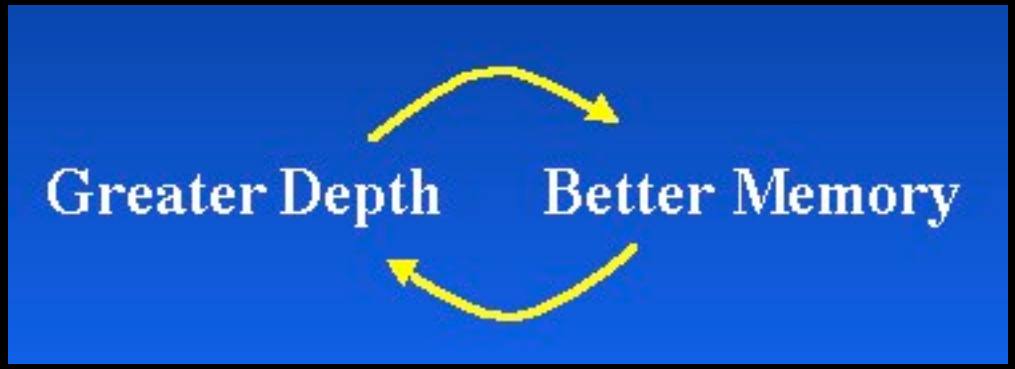
- 1) Intentionally commit words to memory
- 2) Judge pleasantness of words
- 3) Judge whether there is an “e” in the word
- 4) Judge how many letters are in the word



- Memory was better after deep vs. shallow encoding
- Intentional encoding no better than incidental deep encoding

∴ critical factor is the type of processes engaged (i.e., the type of features attended) during encoding, irrespective of why

Difficulties for Depth-of-Processing



Circular Logic: No independent measure of “depth” other than subsequent memory performance

Transfer Appropriate Processing

Is deep encoding always better?

- No. Efficacy of encoding strategy partly depends on what information is needed at test (i.e., depends on what you want to remember)

Transfer appropriate processing

Past processing influences subsequent memory to the extent that the processes engaged at retrieval are similar to those engaged at encoding
(Morris, Bransford, & Franks, 1977)

Operations at encoding and at retrieval can vary from perceptually–driven to conceptually–driven. Test performance will be optimal when the two match.

TAP: Morris et al. (1977) study

Subjects performed one of two study tasks

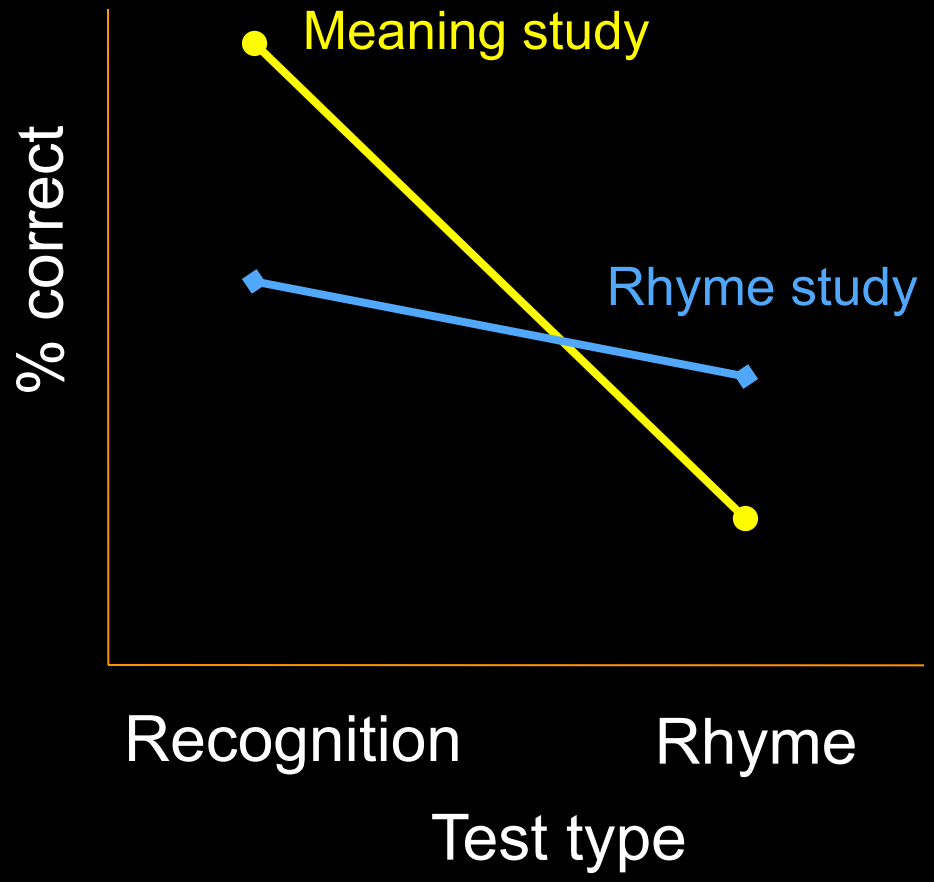
- In each case, they had to say whether a target word fit into the blank
- Meaning condition
  - The _____ was on the shelf
    - "book" - yes or no
- Phonology (rhyme) condition
  - _____ rhymes with fear
    - "spear" - yes or no

Memory was measured using two different types of test

- Recognition test ("Did you see 'book' before?")
- Rhyme cued-recall ("Did you see a word that rhymes with 'clear' before?")

TAP: Morris et al. (1977) results

- Recognition performance was better following meaning task
- Rhyme cued-recall performance was better following rhyming task
- Deep study is not always better



Implications from Depth of Processing

- Levels of processing differ with respect to:
  - Which features of an item/event are encoded
  - The degree to which new information is related to prior knowledge
- Semantic (deep) processing may be more distinctive, leading to less interference across items
- Semantic processing links new information to existing knowledge, providing more retrieval cues at test

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Other Factors that Optimize Memory

Factors that maximize memory retention over shorter delays often result in poor long-term retention

- Can lead to overestimation of learning
- Optimal learning requires “desirable difficulties”

What maximizes long-term retention?

- Retrieval as a way to learning
  - Tests are the best way to learn and retain information
- Spaced practice

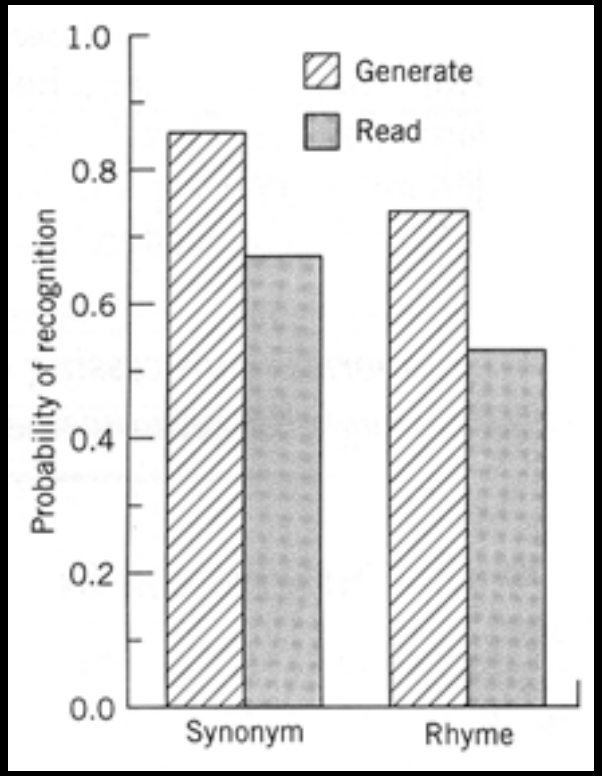
The Generation Effect

READ Conditions:

Synonym	Unhappy – SAD
Rhyme	Lad – SAD

GENERATE Conditions:

Synonym	Unhappy – S___?
Rhyme	Lad – S__?



- You are more likely to remember material if you generate it yourself, rather than simply being exposed to it

Power of Retrieval as an Encoding Event: Roediger & Karpicke (2006)

Subjects were given a text passage to learn

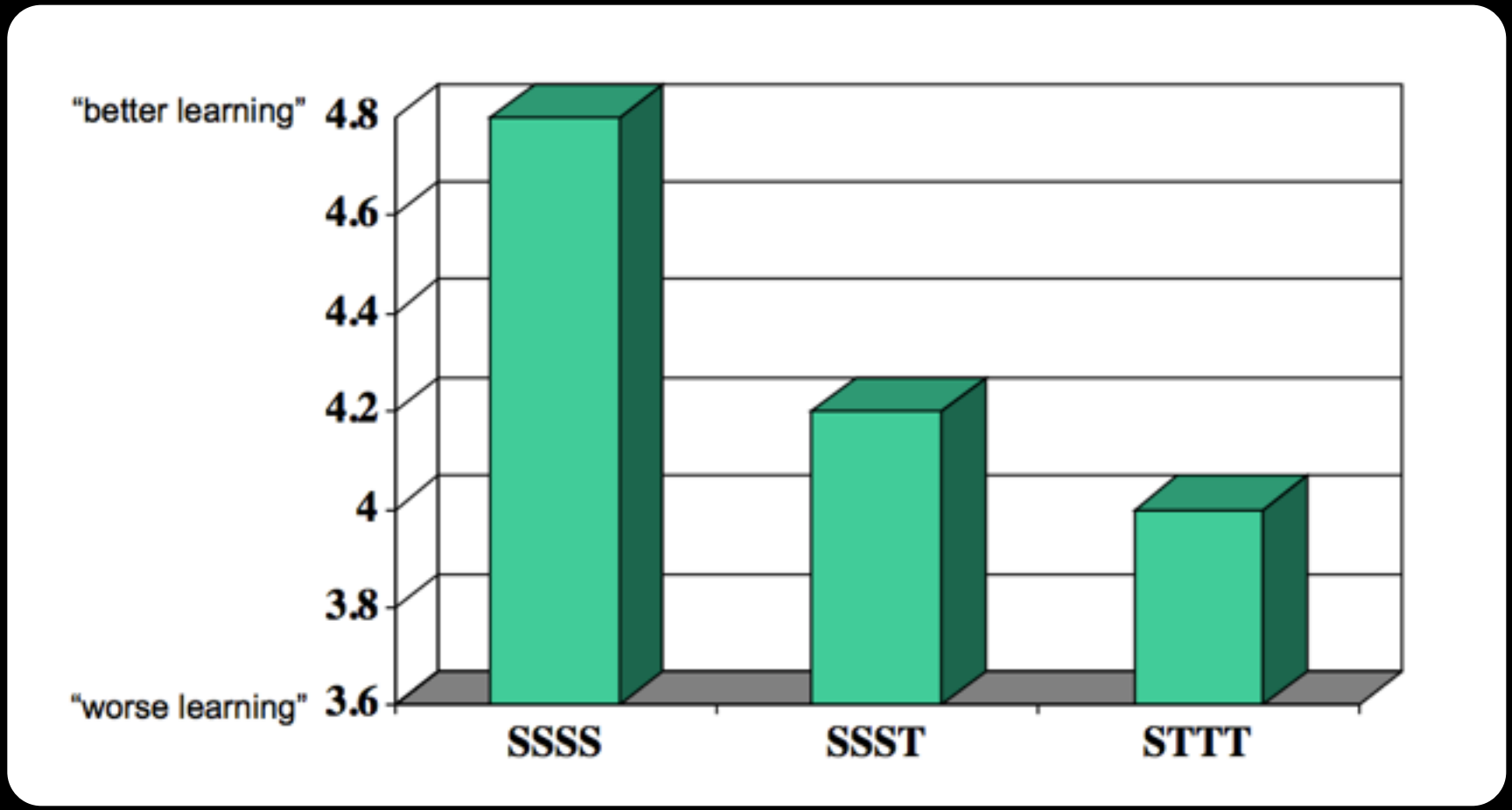
Three learning conditions

- SSSS: four study presentations (i.e., four times reading the passage)
- SSST: three study presentations followed by one test
- STTT: one study presentation followed by three tests

Either 5 minutes or 1 week later

- Asked how well they felt they had learned the material (*Judgment of Learning; JOL*)
- Then tested on how well they retained the ideas from the passage

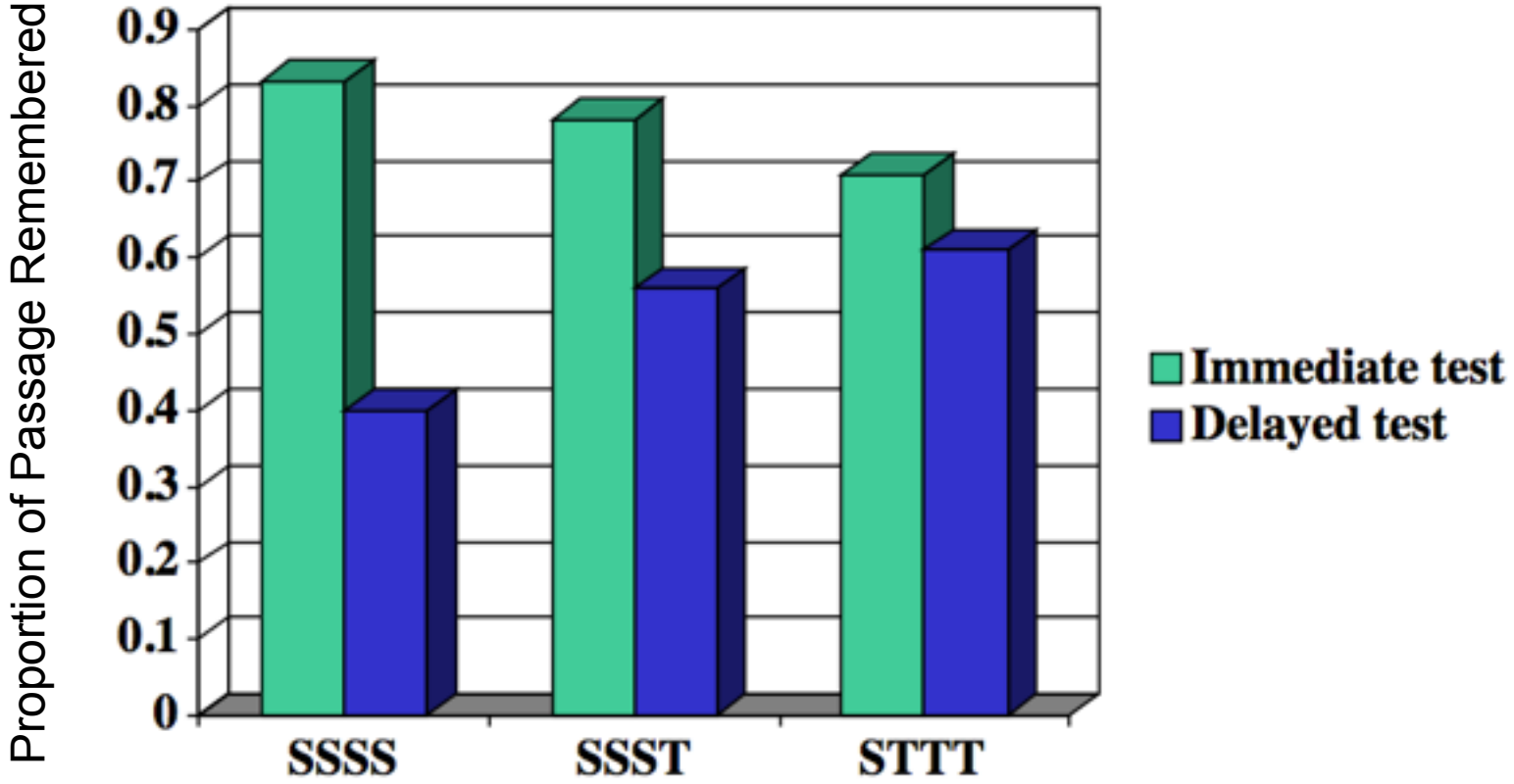
Judgments of Learning (JOL)



Subjects in SSSS felt that they had learned the material better than the other groups

Roediger & Karpicke, 2006

Memory Performance



Testing promotes better long-term retention than repeated studying

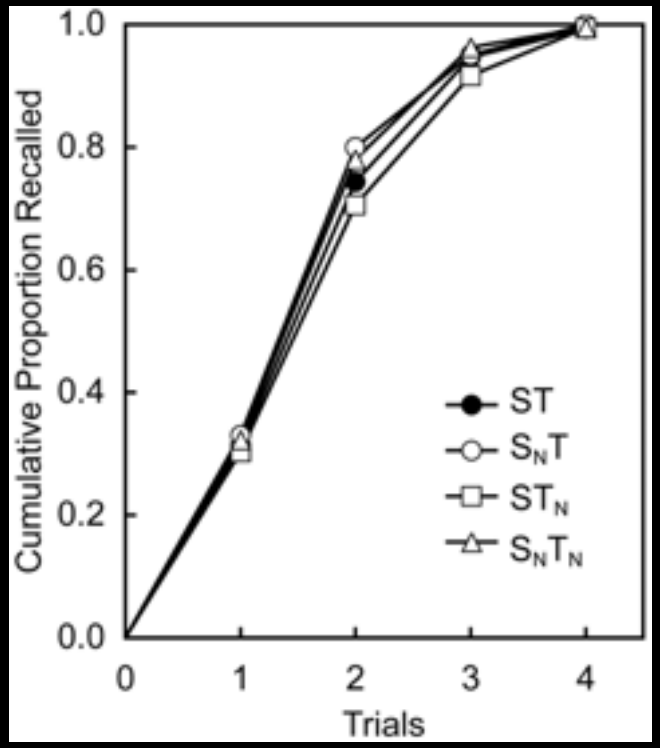
Roediger & Karpicke, 2006

Roediger & Karpicke (2008)

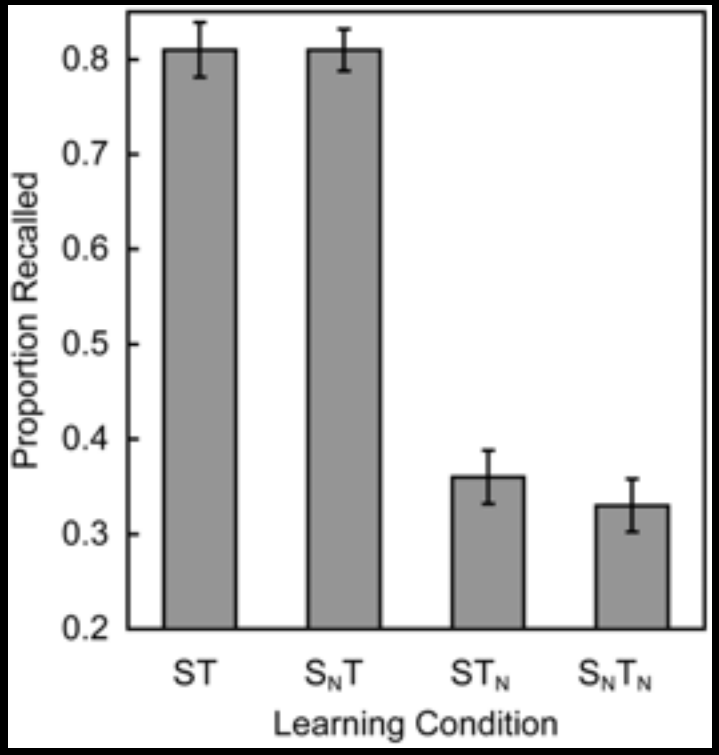
- Participants learned Swahili-English translations (e.g., mashua – boat) over repeated study-test cycles
- Assigned to one of four strategies:
  - Present all items for each study/test cycle (ST)
  - Present non-recalled items during study, but test all items ($S_N T$)
  - Present all items during study, but test non-recalled items (ST_N)
  - Present and test non-recalled items ($S_N T_N$)
- Recall tested one week later

Roediger & Karpicke (2008)

During learning cycles



Test after 1-week delay



- Studying information you already know without testing is ineffective ($ST > ST_N$)
- Being tested once isn't as effective as repeated testing ($S_NT > S_NT_N$)

Next time…

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  - Attention
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  - Repetition and Spacing
- Amnesia (anterograde and retrograde)
- Medial Temporal Lobe and Episodic Memory

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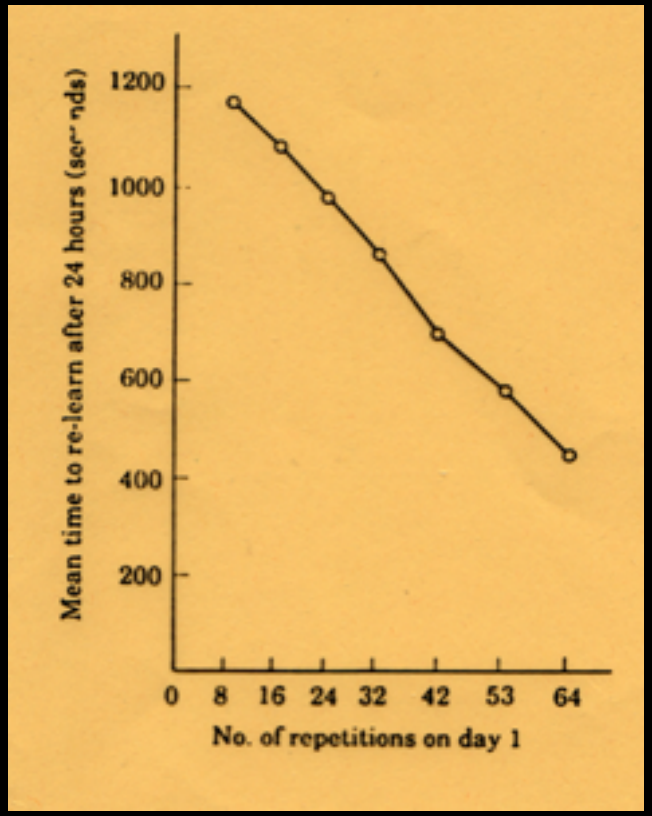
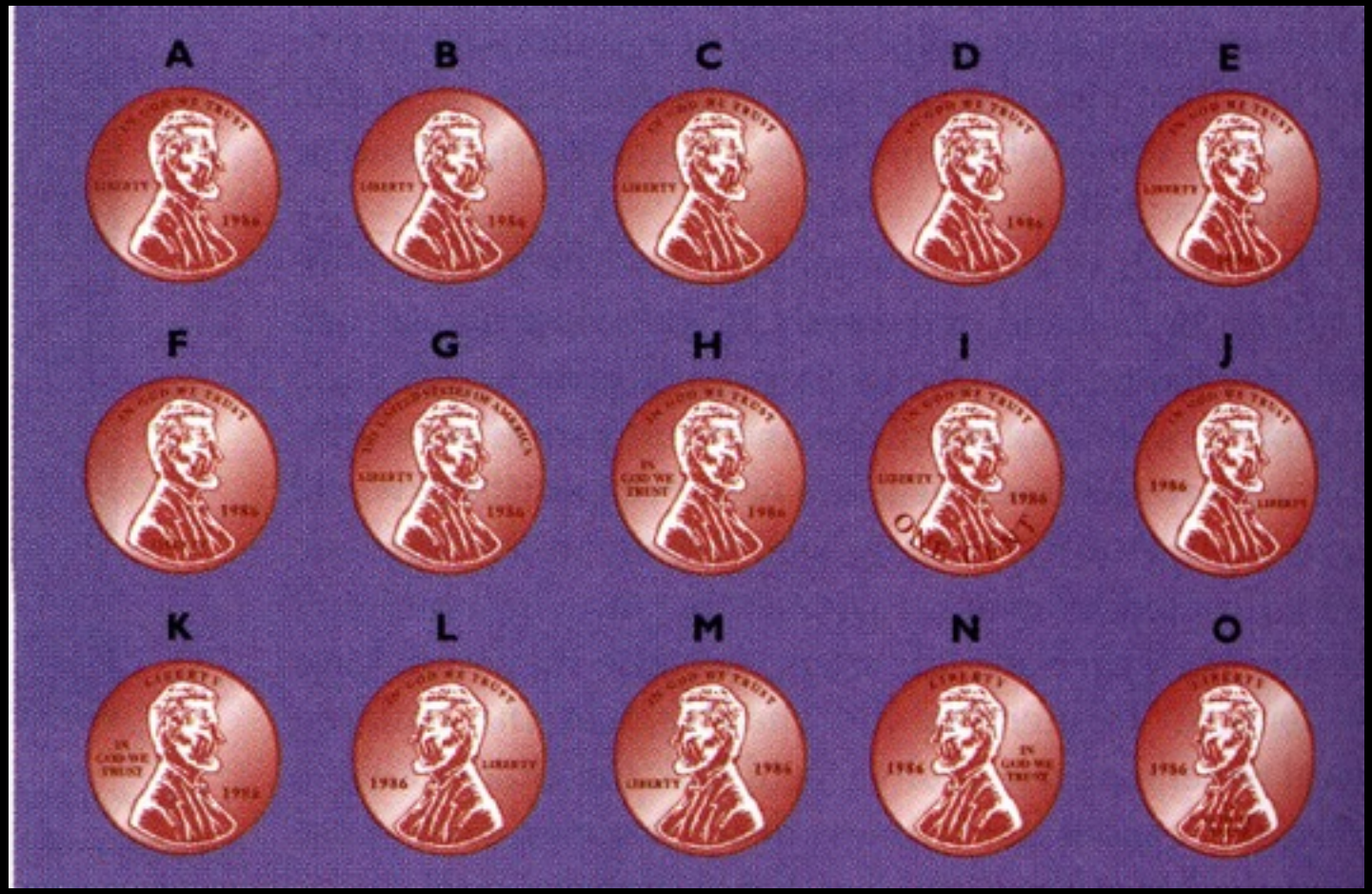
Ebbinghaus on Repetition

- Found that repeatedly studying words reduced forgetting
  - The more repetitions, the better his memory performance



Caveat: Repetition isn't Enough



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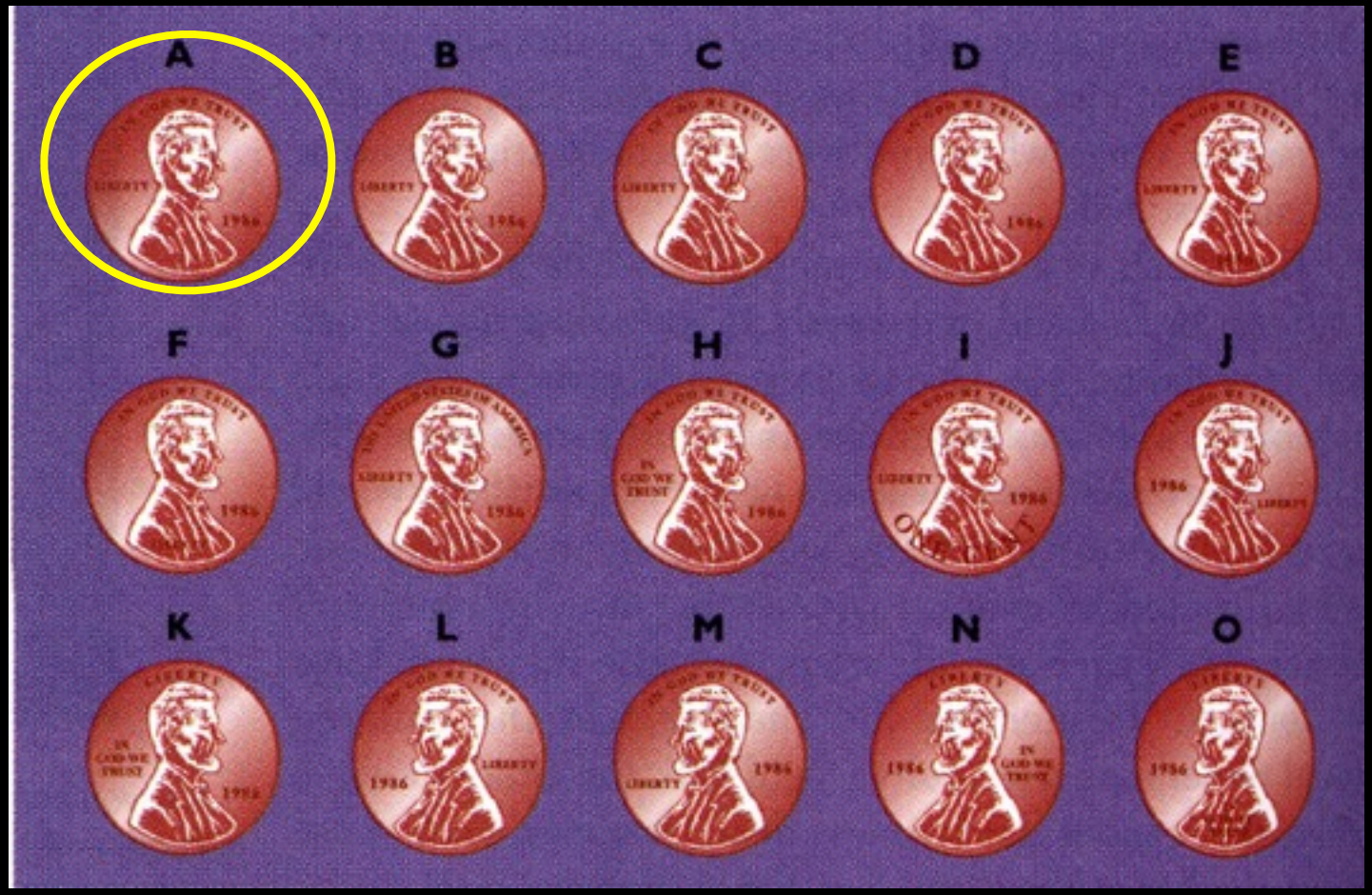
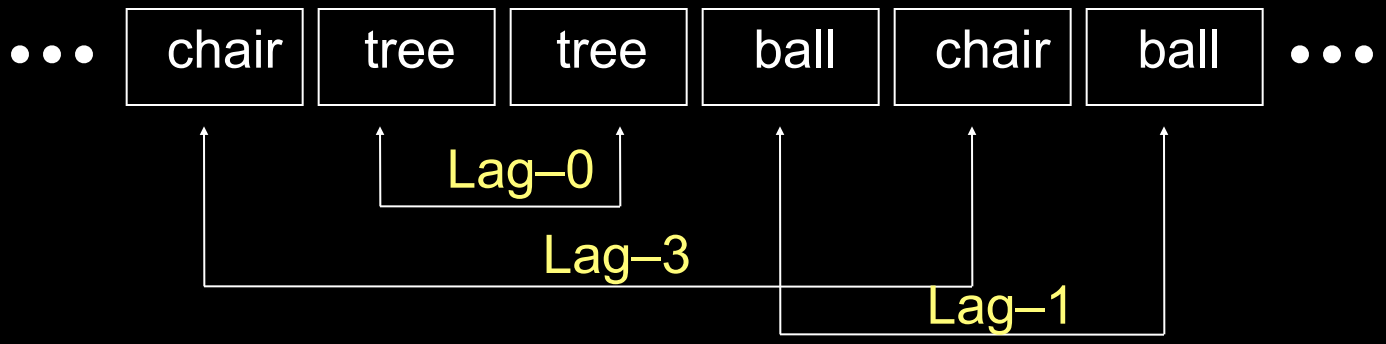


Merely being exposed to information repeatedly doesn't ensure that it will be well learned!

Distribution of Practice

Not all encoding events are created equal

"with any considerable number of repetitions a suitable distribution of them over a space of time is decidedly more advantageous than the massing of them at a single time" – Ebbinghaus (1885)



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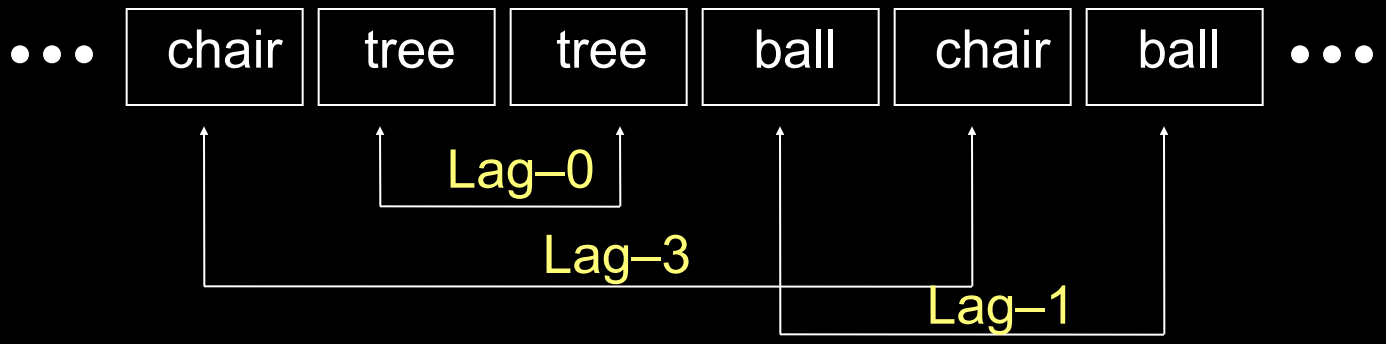


Spaced Practice (Spacing Effect)

- greater lags between practice/study trials yield better long-term retention

The Spacing Effect

Jacoby (1978) Procedure

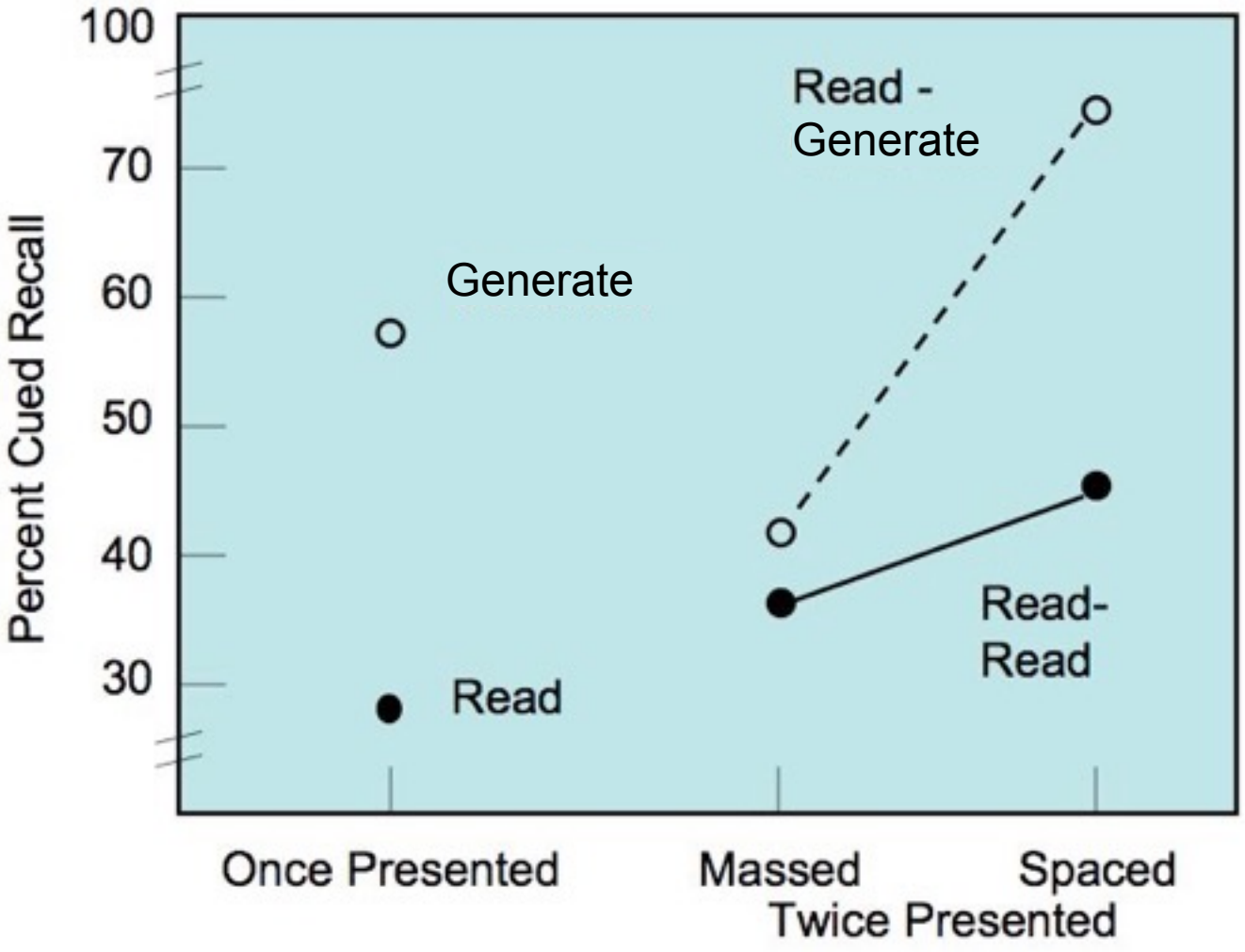
Study Phase

Once-Presented Pairs	Twice-Presented Pairs	
	Massed	Spaced
Foot Shoe (*Read*)	Foot Shoe	Foot Shoe
OR	Foot Shoe	***(20 other pairs intervene)***
Foot S - - e (*Generate*)	**OR**	Foot Shoe
	Foot Shoe	**OR**
	Foot S - - e	Foot Shoe
		(20 other pairs intervene)
		Foot S- - e

Test Phase (Cued Recall)

Foot ????

Jacoby (1978)


100
70
60
50
40
30
Percent Cued Recall
Read -
Generate
Generate
Read-
Read
Read
Once Presented
Massed
Spaced
Twice Presented

Understanding the Spacing Effect

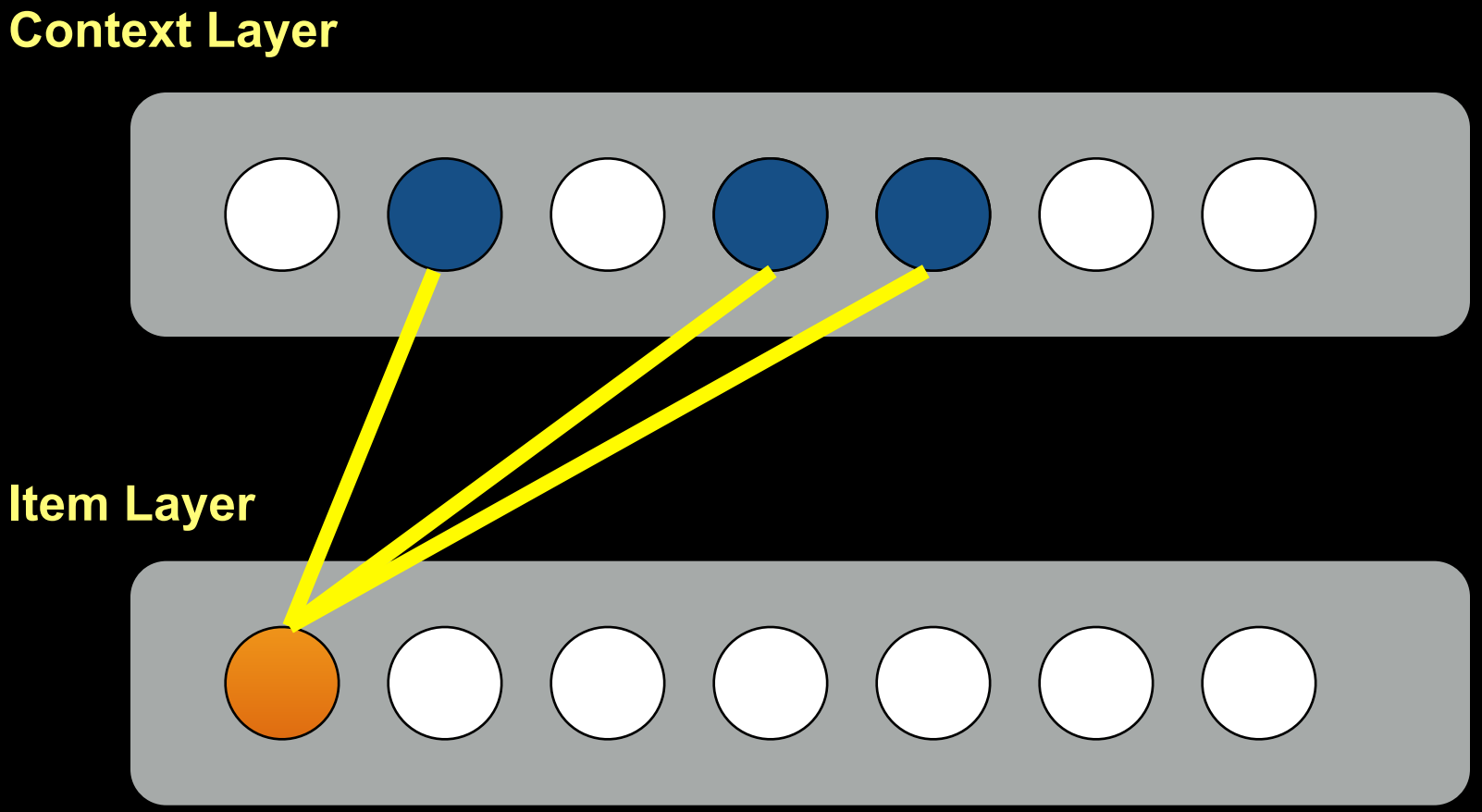
Deficient processing: during massed practice, repeated occurrences of an item are not processed fully

- less attention to items just processed

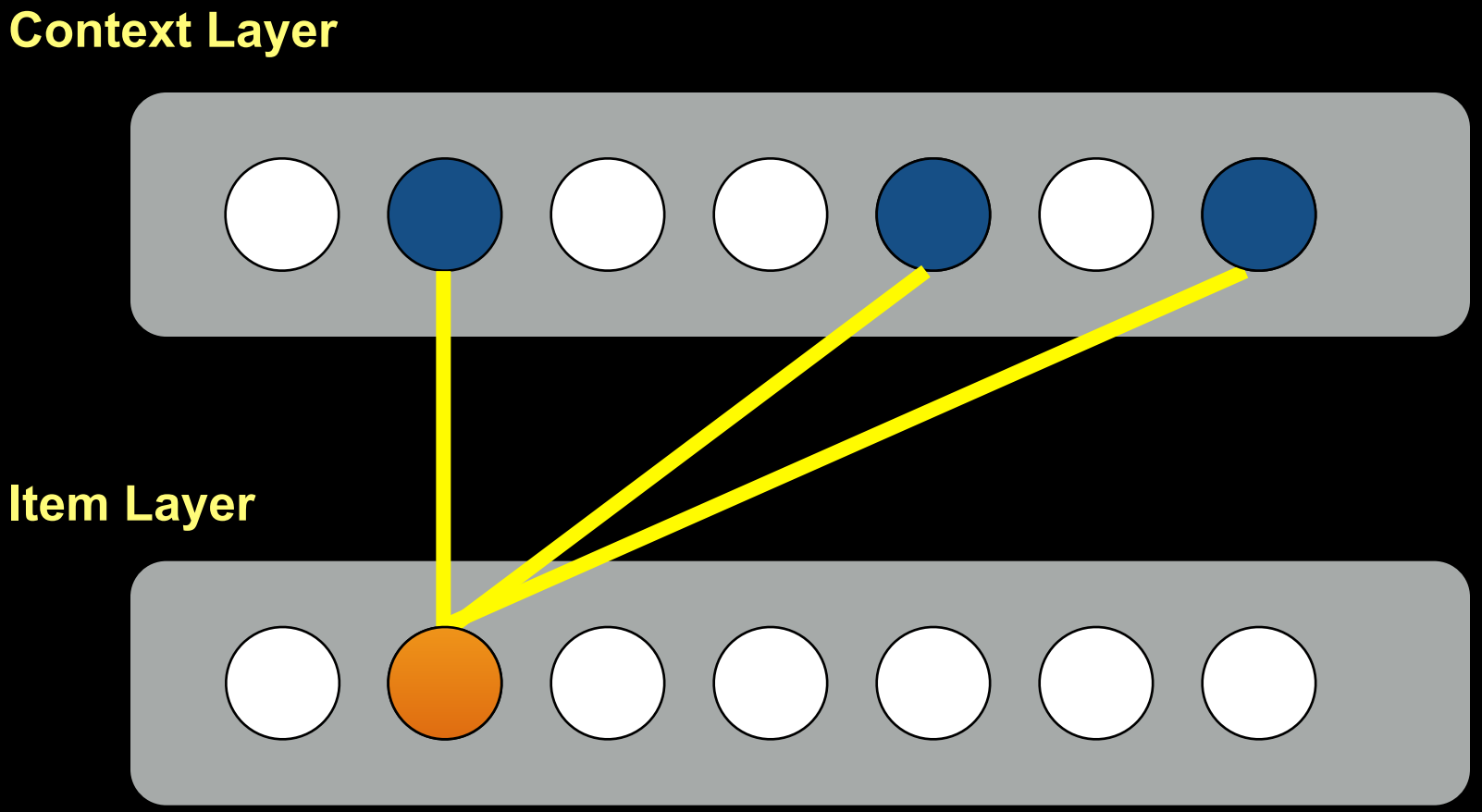
Encoding variability: longer lags result in more variable encoding

- variable encoding: e.g., different encoding contexts; different ways of elaborating on the material
- variability may derive from context fluctuations across time (Estes' stimulus sampling theory; see Fig 1.8)
- variable encoding allows for enhanced subsequent retrieval because one can rely on multiple retrieval cues

Episodic Memory:
Binding of Items and Context



Episodic Memory:
Binding of Items and Context



Episodic Memory:
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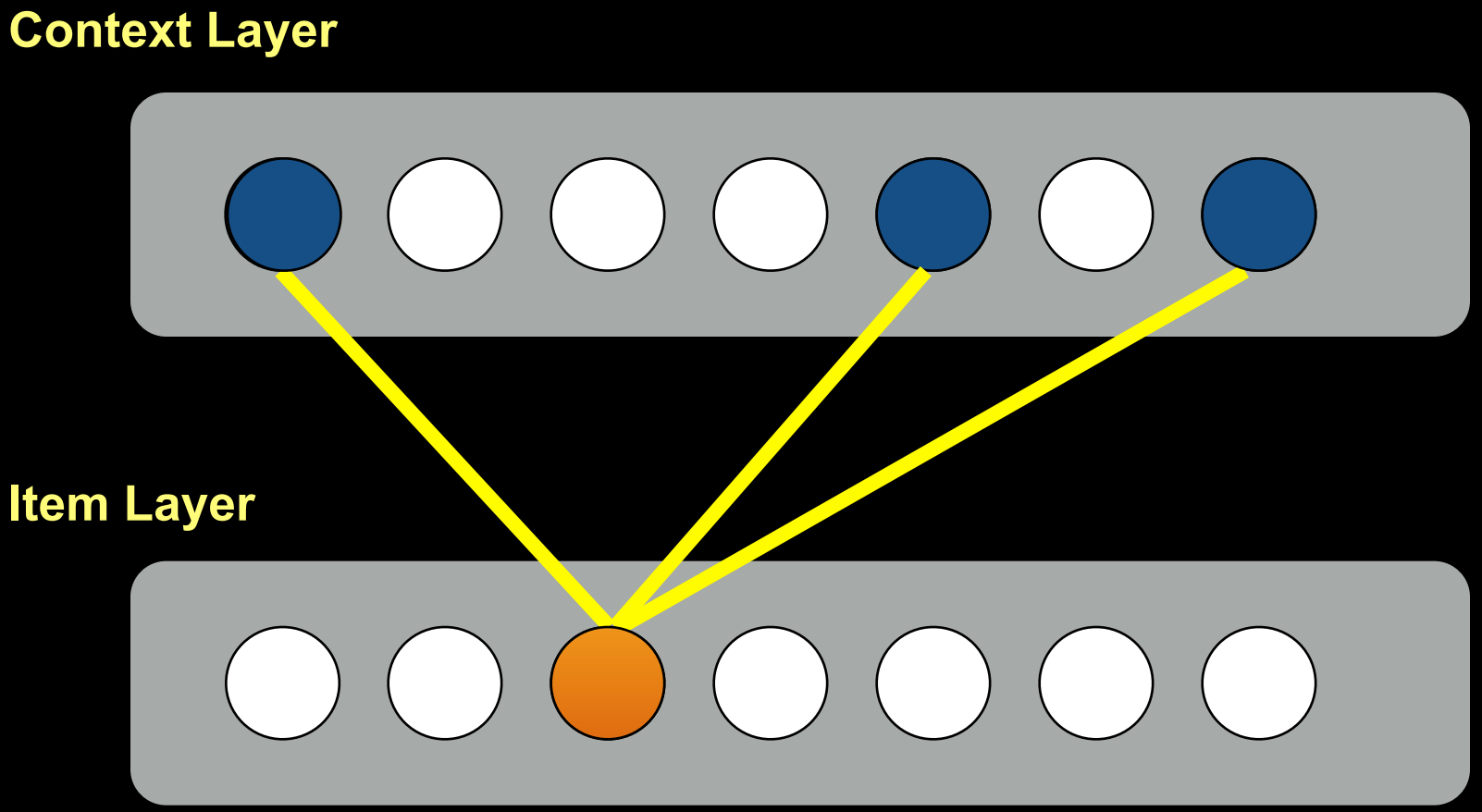

Episodic Memory:
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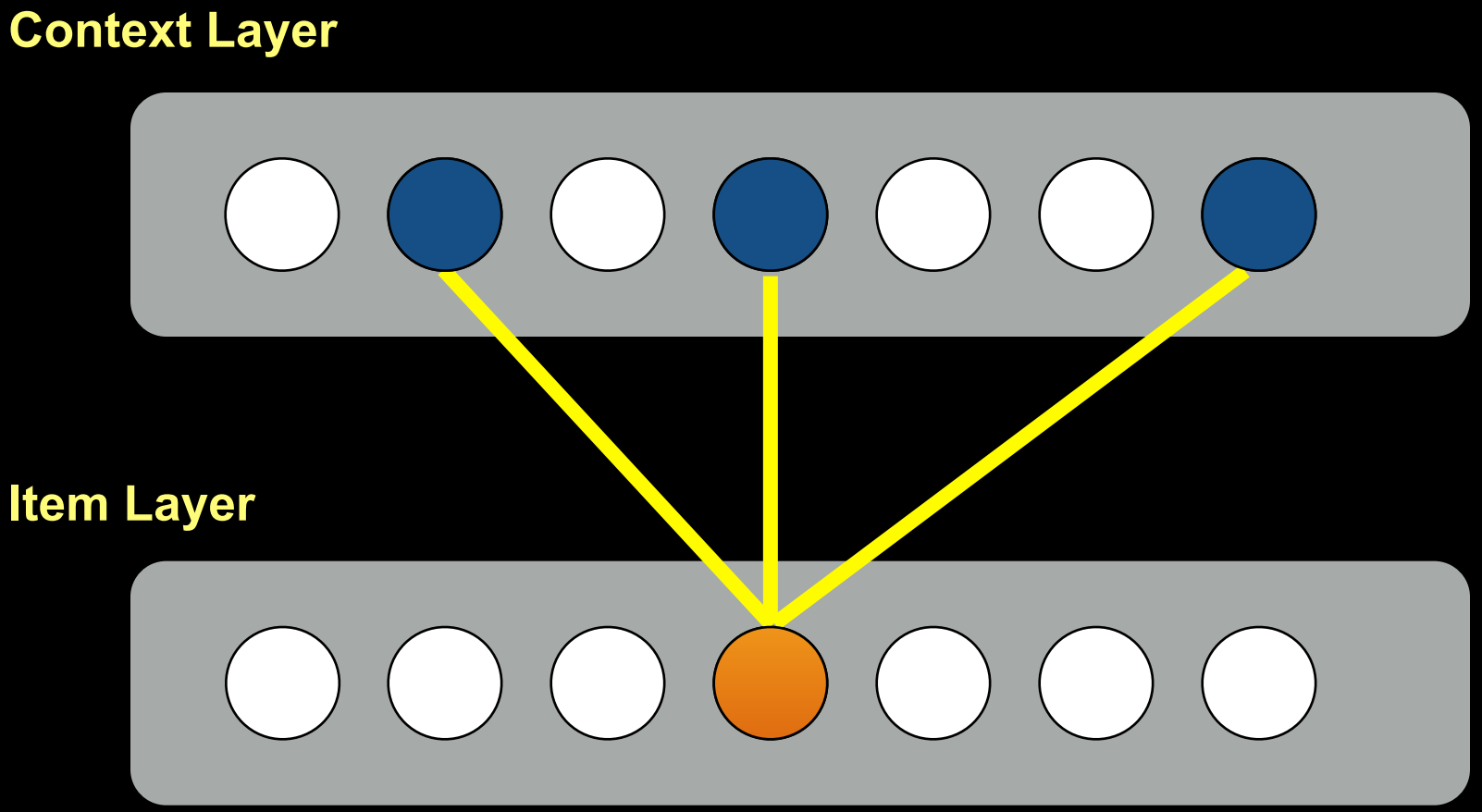
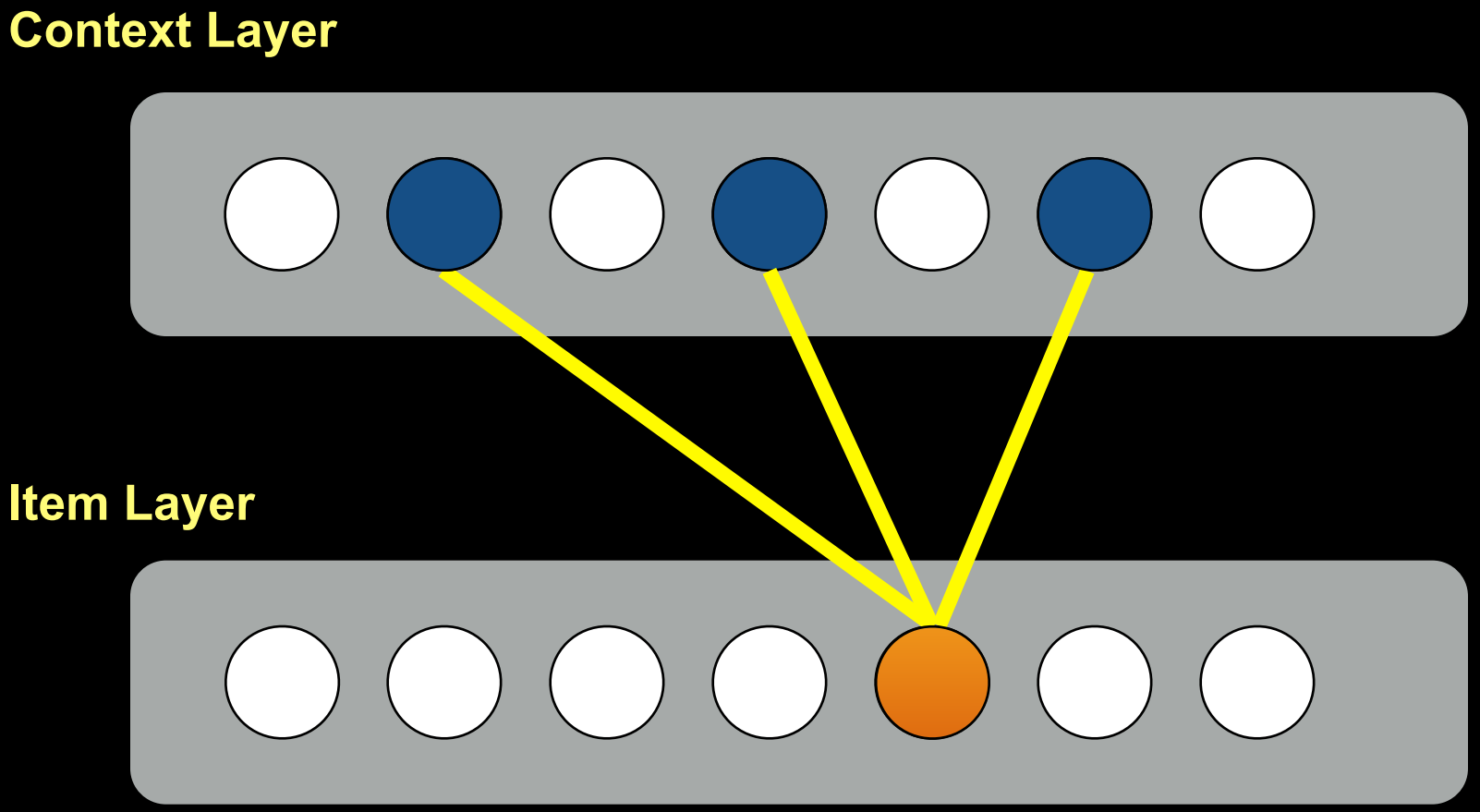


Episodic Memory:
Binding of Items and Context



Episodic Memory:
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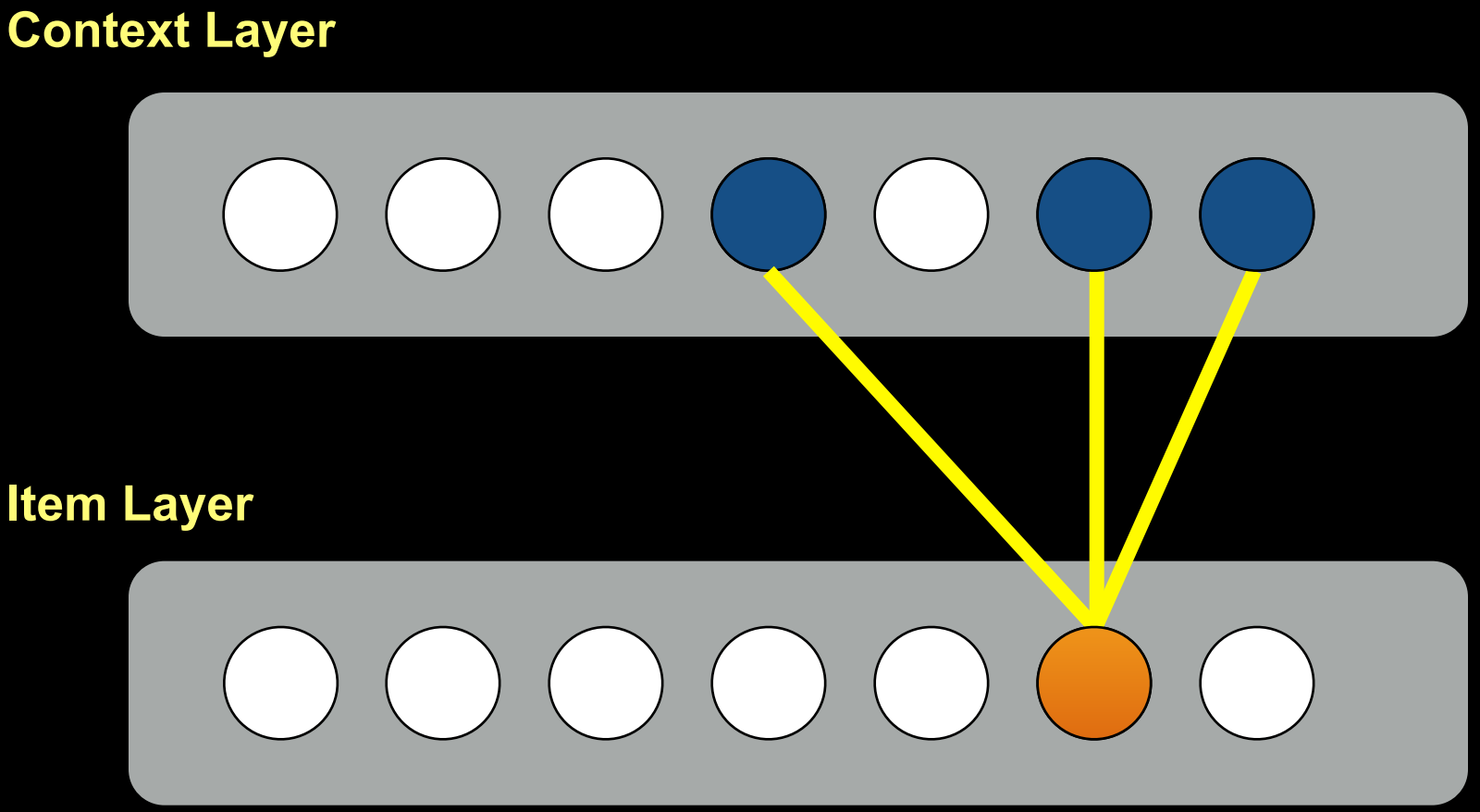

Episodic Memory:
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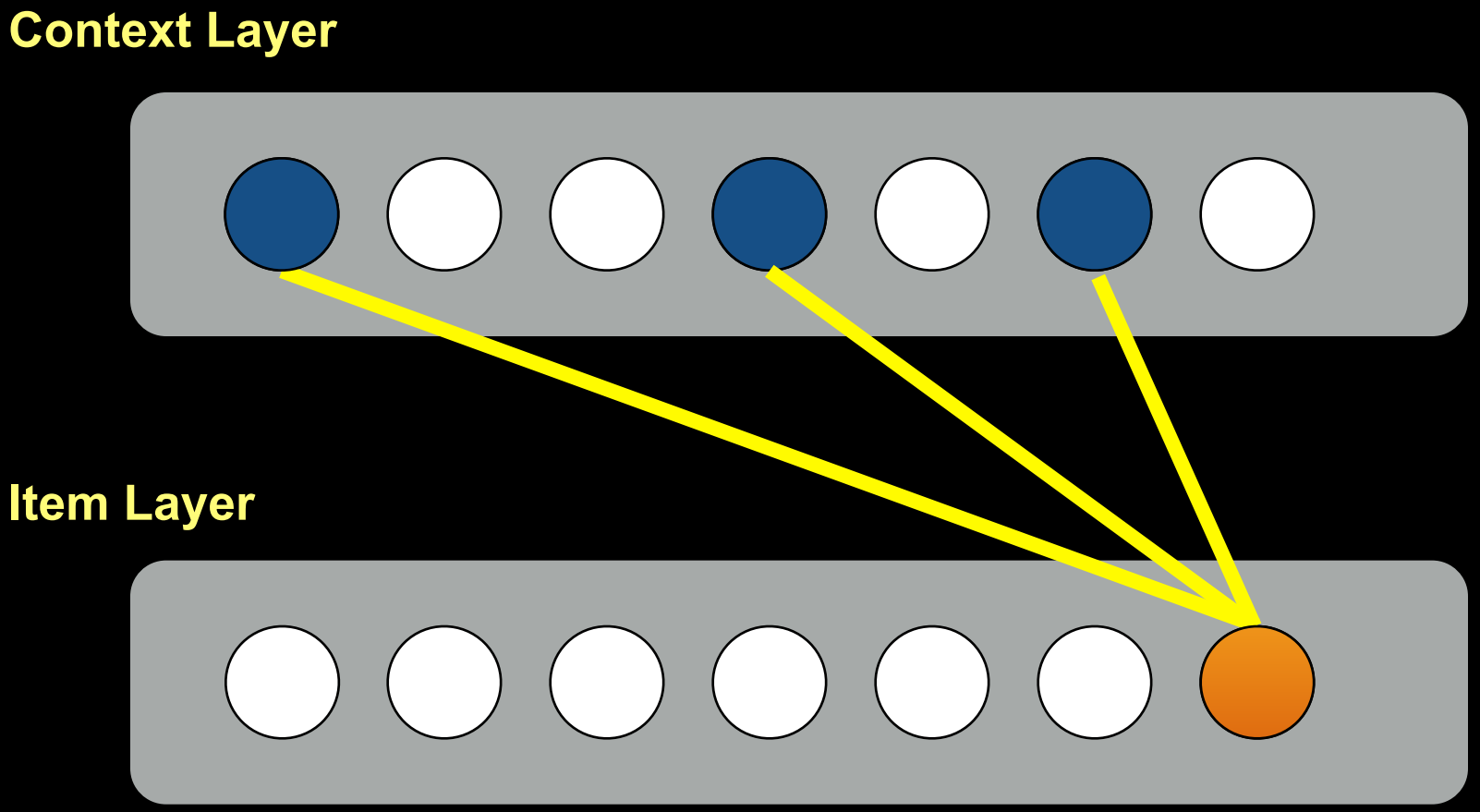
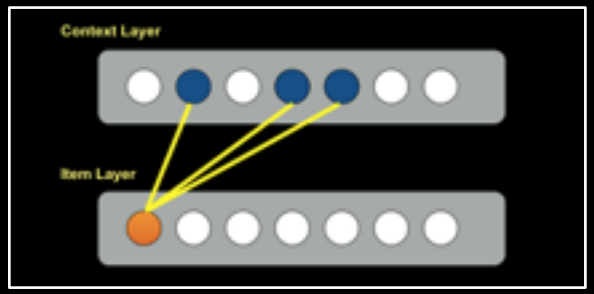


Stimulus Sampling Theory & Spacing

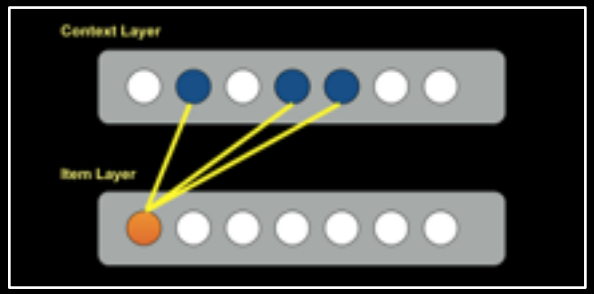
Massed Practice

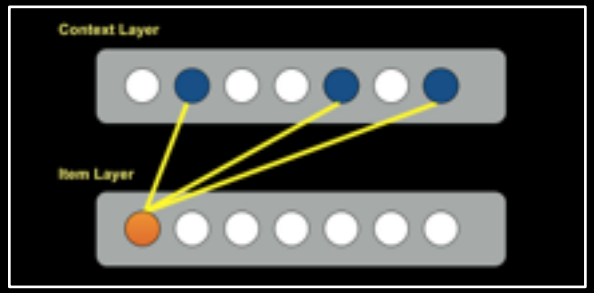


Spaced Practice

Stimulus Sampling Theory & Spacing

Massed Practice

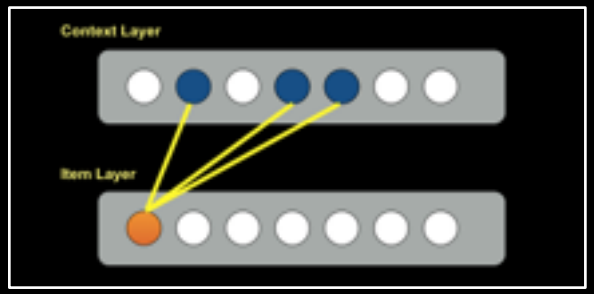


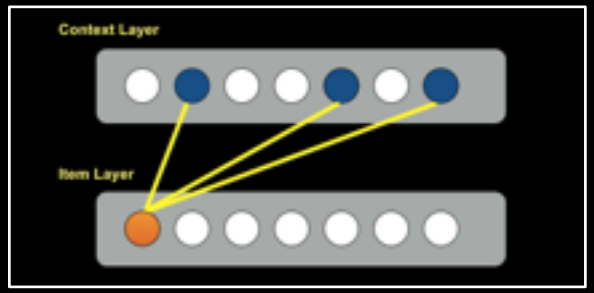


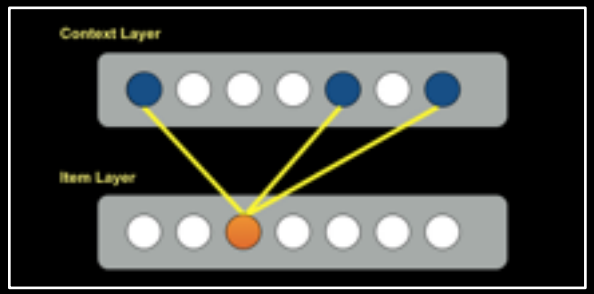
Spaced Practice

Stimulus Sampling Theory & Spacing

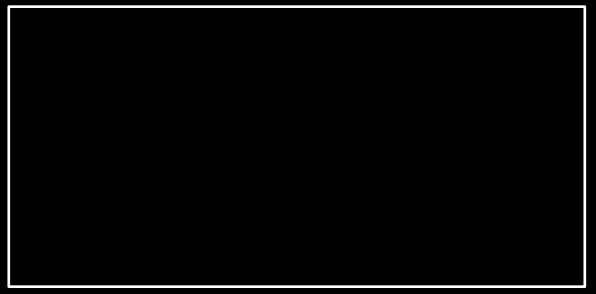
Massed Practice

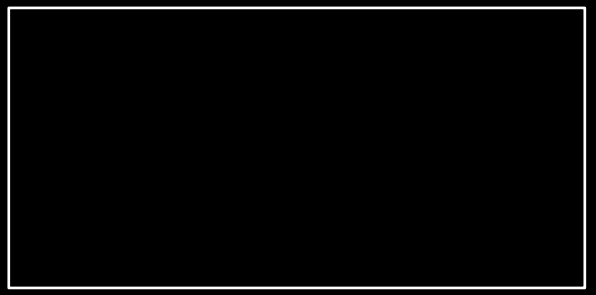


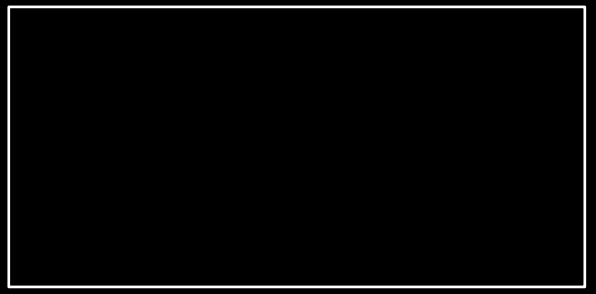




Spaced Practice

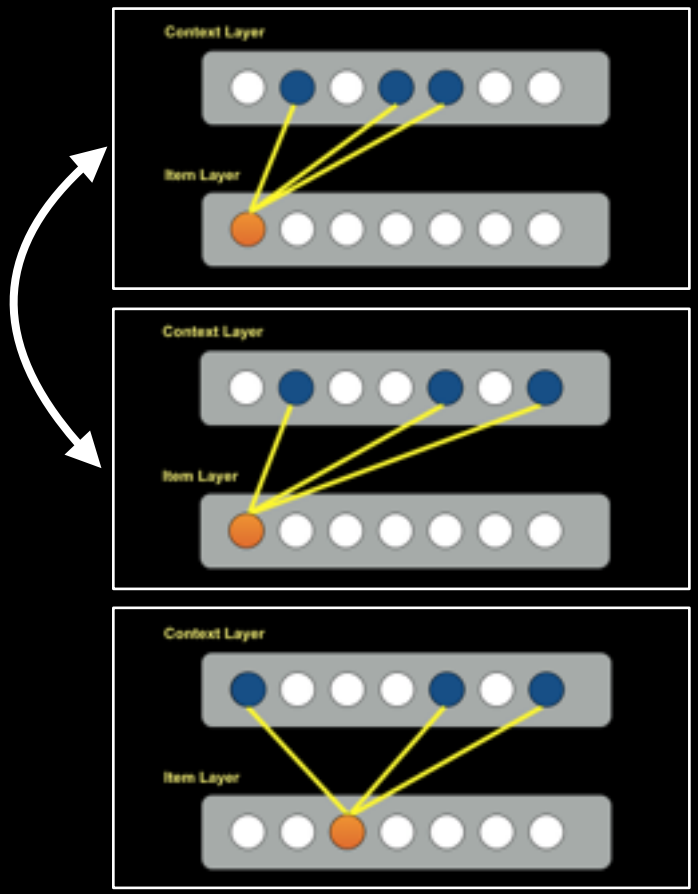






Stimulus Sampling Theory & Spacing

Massed Practice



Spaced Practice

Stimulus Sampling Theory & Spacing

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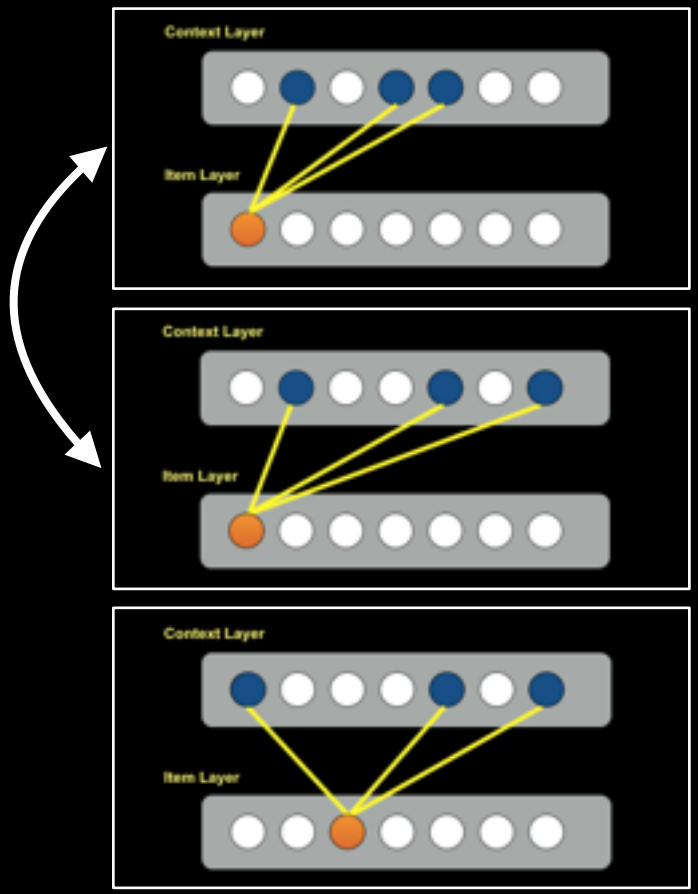

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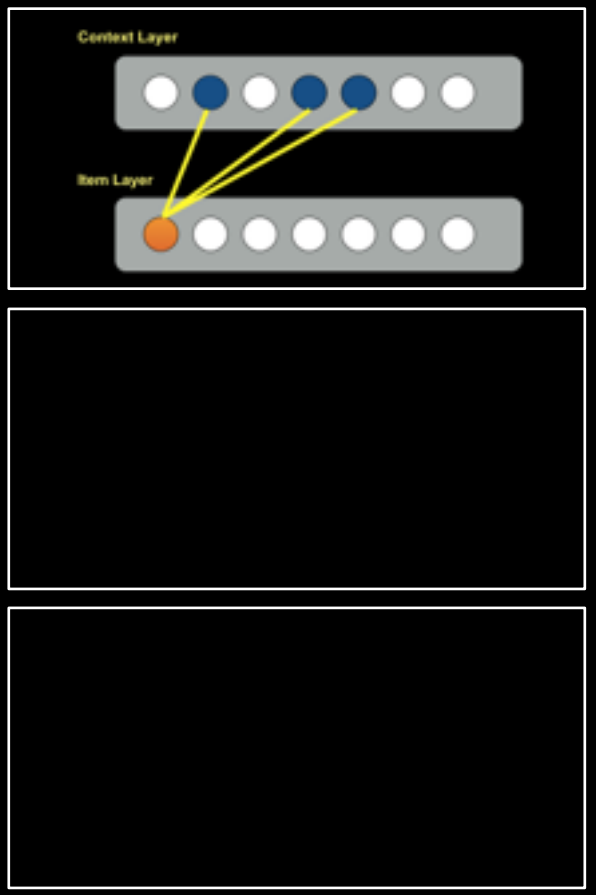

Stimulus Sampling Theory & Spacing

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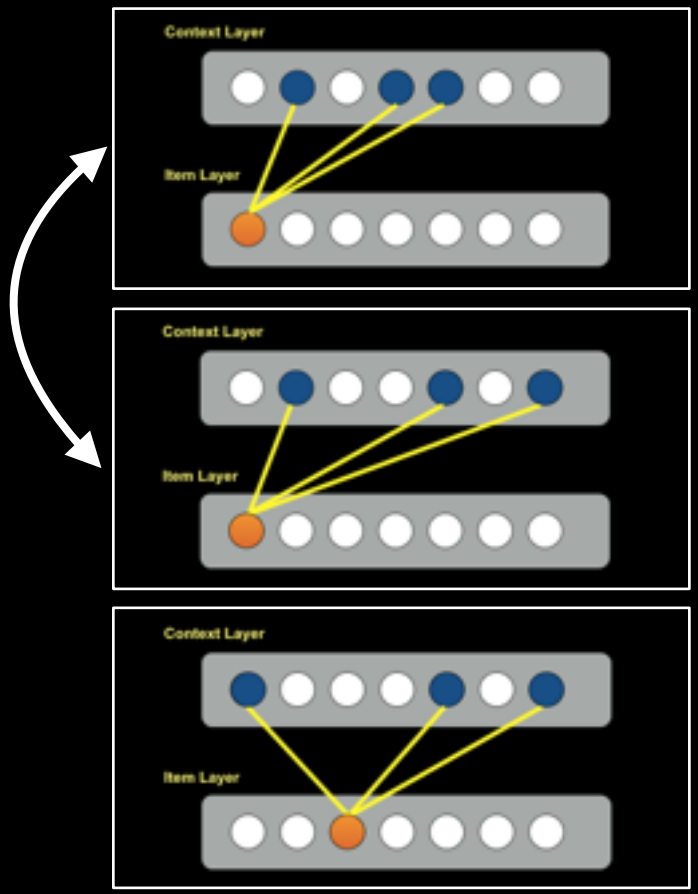

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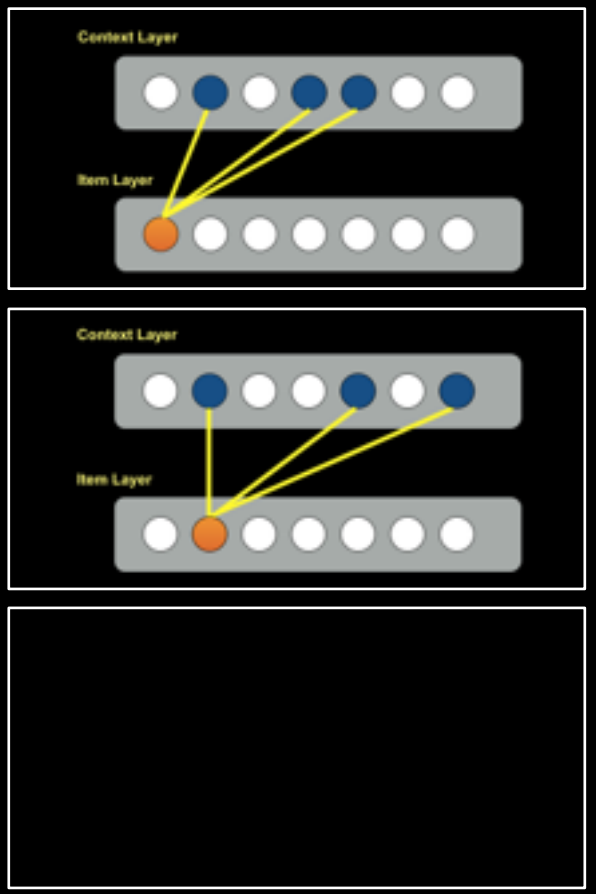

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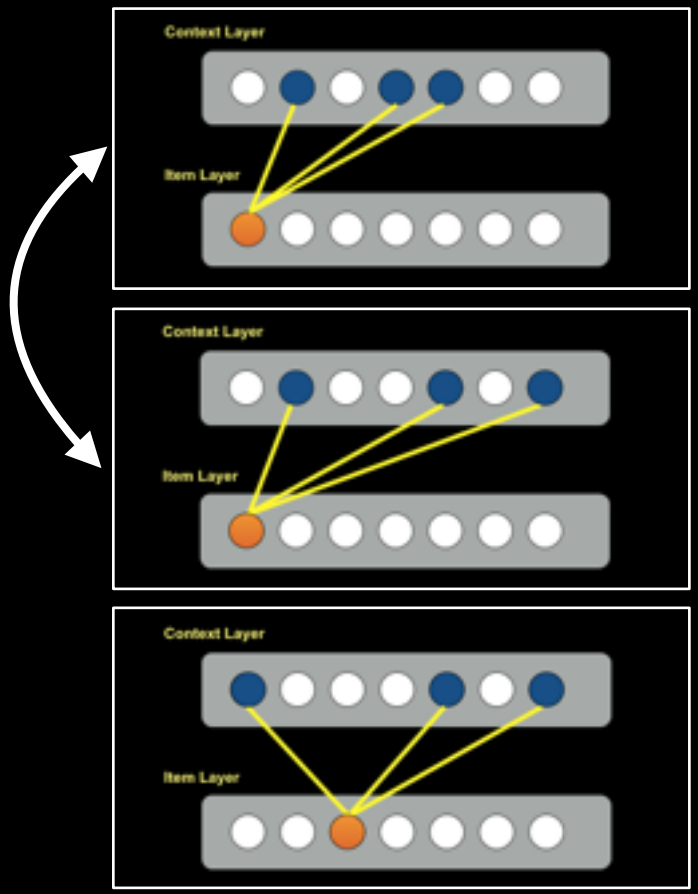
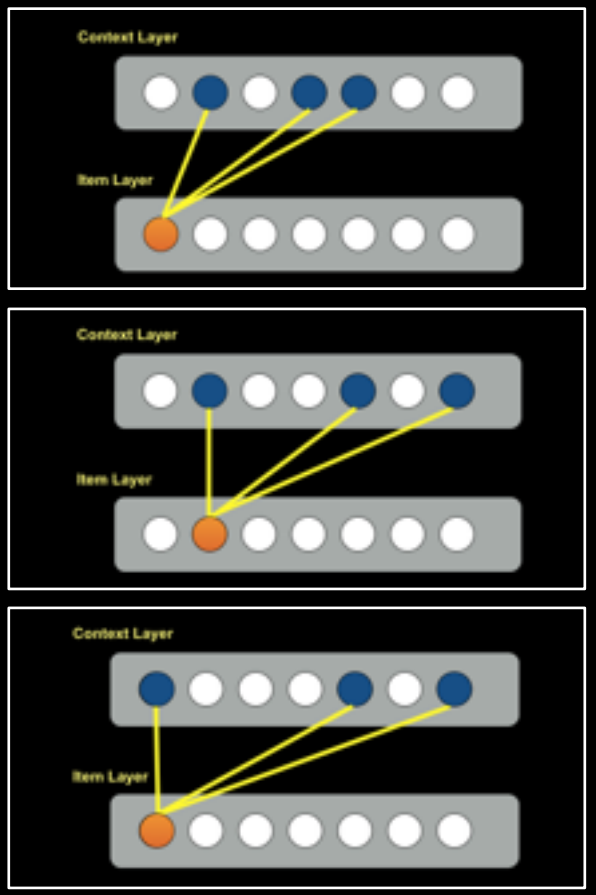
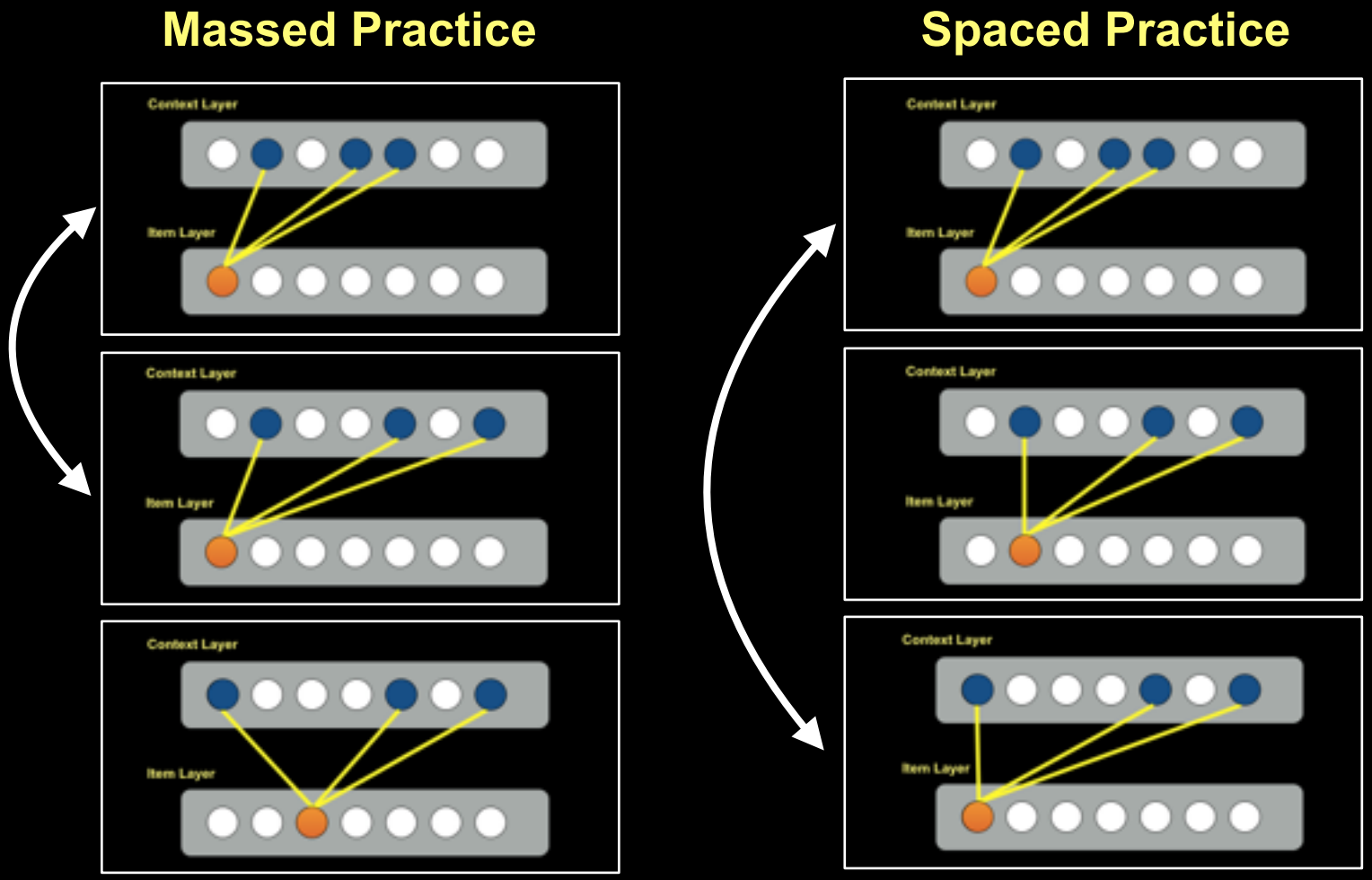


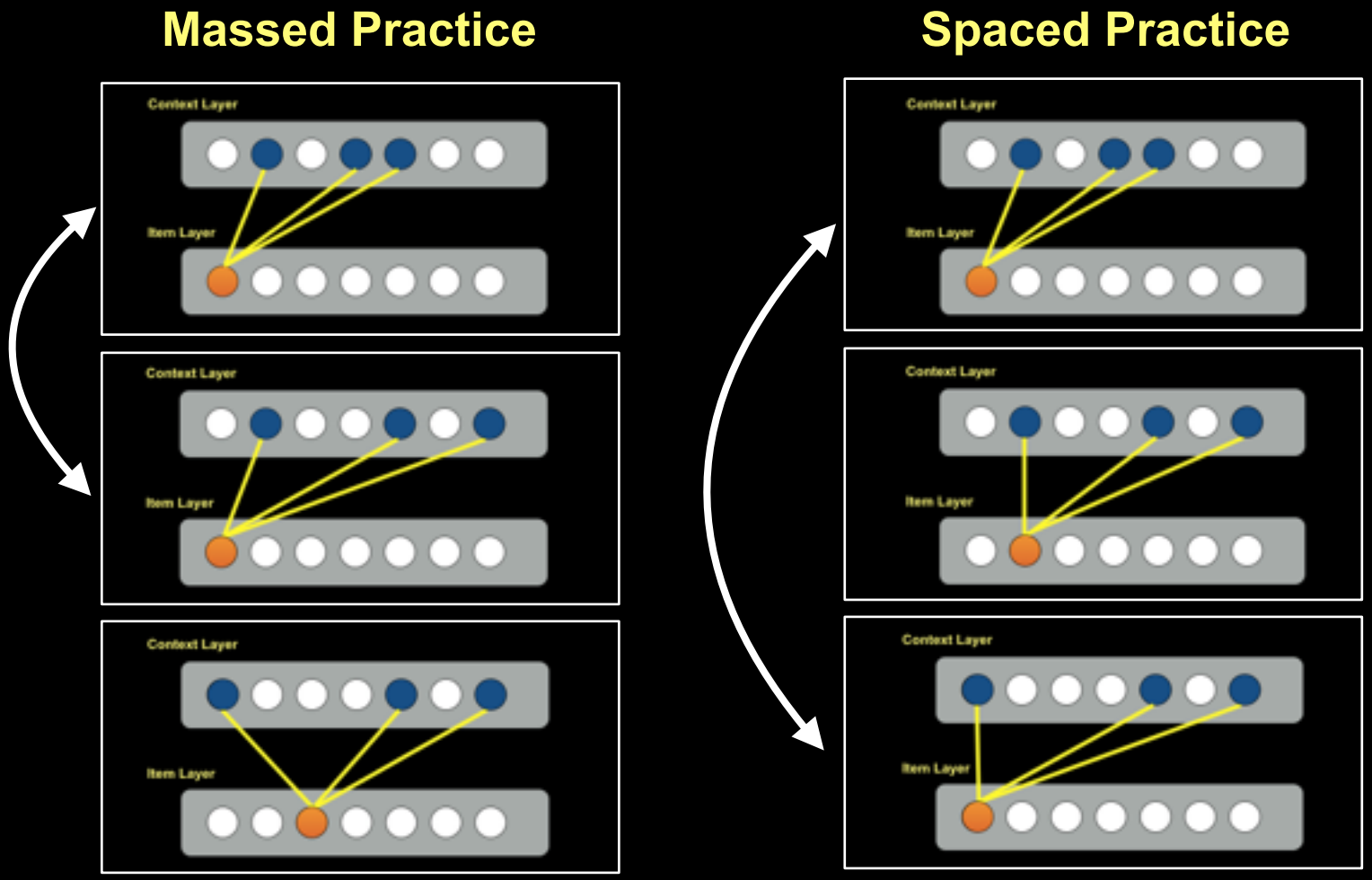
Spaced Practice



Stimulus Sampling Theory & Spacing



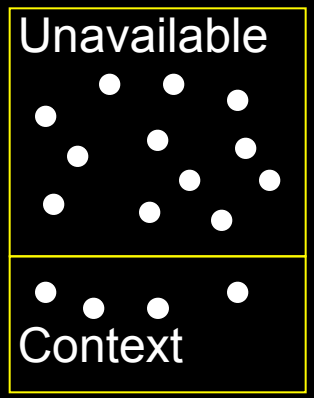
Stimulus Sampling Theory & Spacing



More context features are bound to the item following spaced practice. Results in more cues to support retrieval.

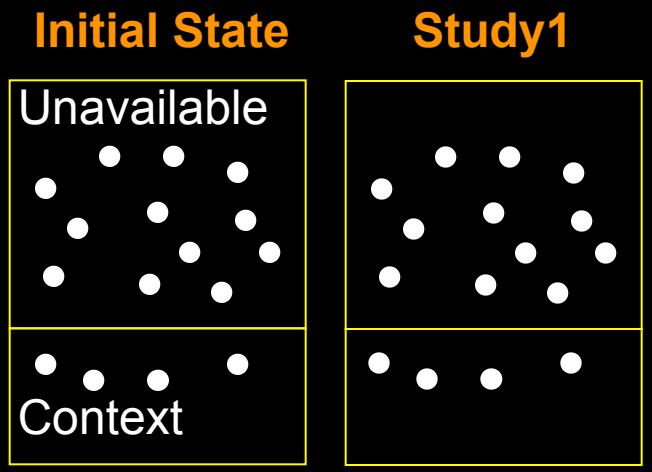
Stimulus Sampling Theory & Spacing

Initial State



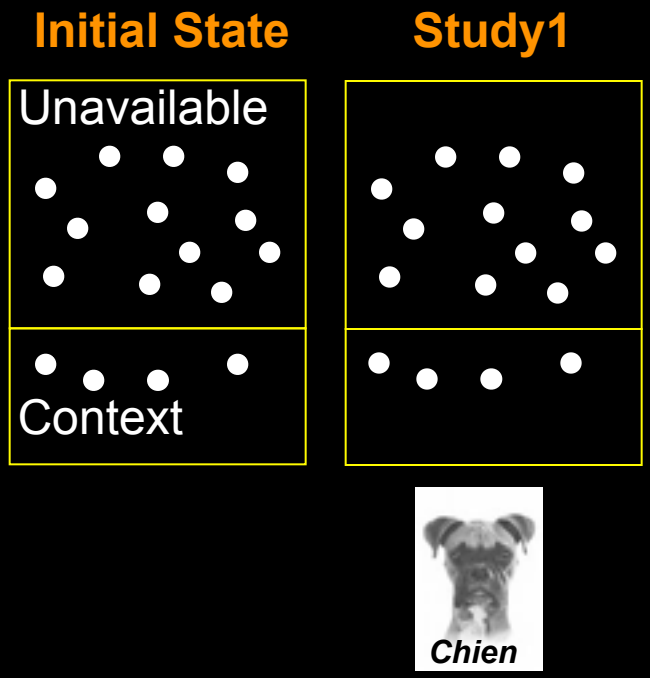
(Estes, 1955)

Stimulus Sampling Theory & Spacing



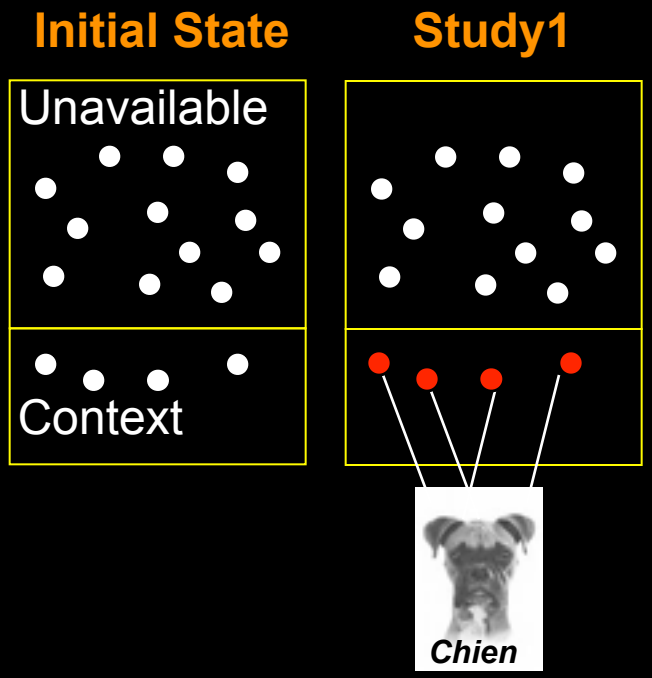
(Estes, 1955)

Stimulus Sampling Theory & Spacing



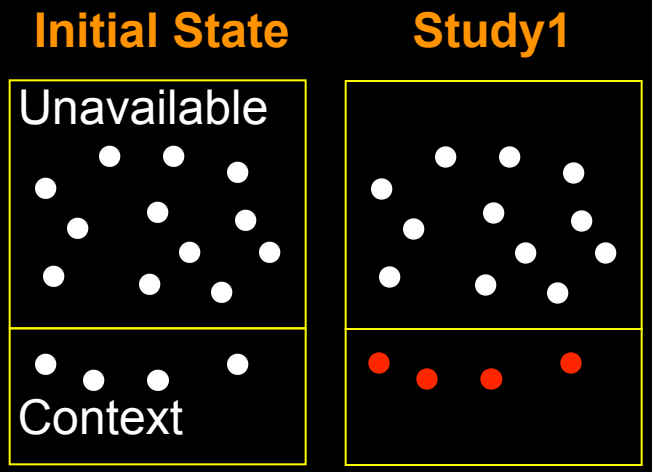
(Estes, 1955)

Stimulus Sampling Theory & Spacing



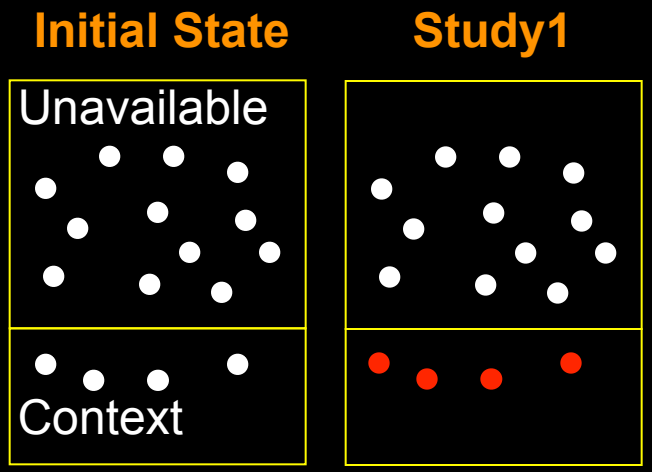
(Estes, 1955)

Stimulus Sampling Theory & Spacing



(Estes, 1955)

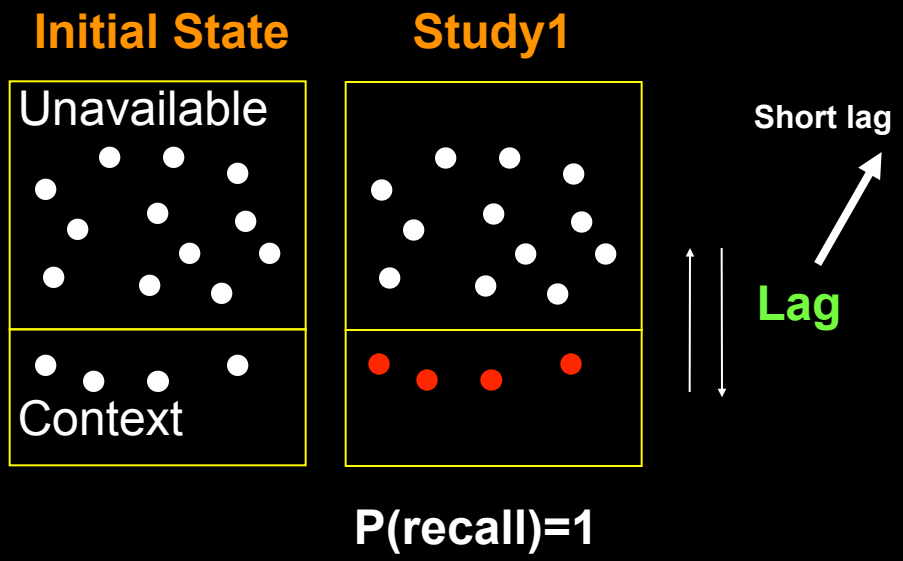
Stimulus Sampling Theory & Spacing



P(recall)=1

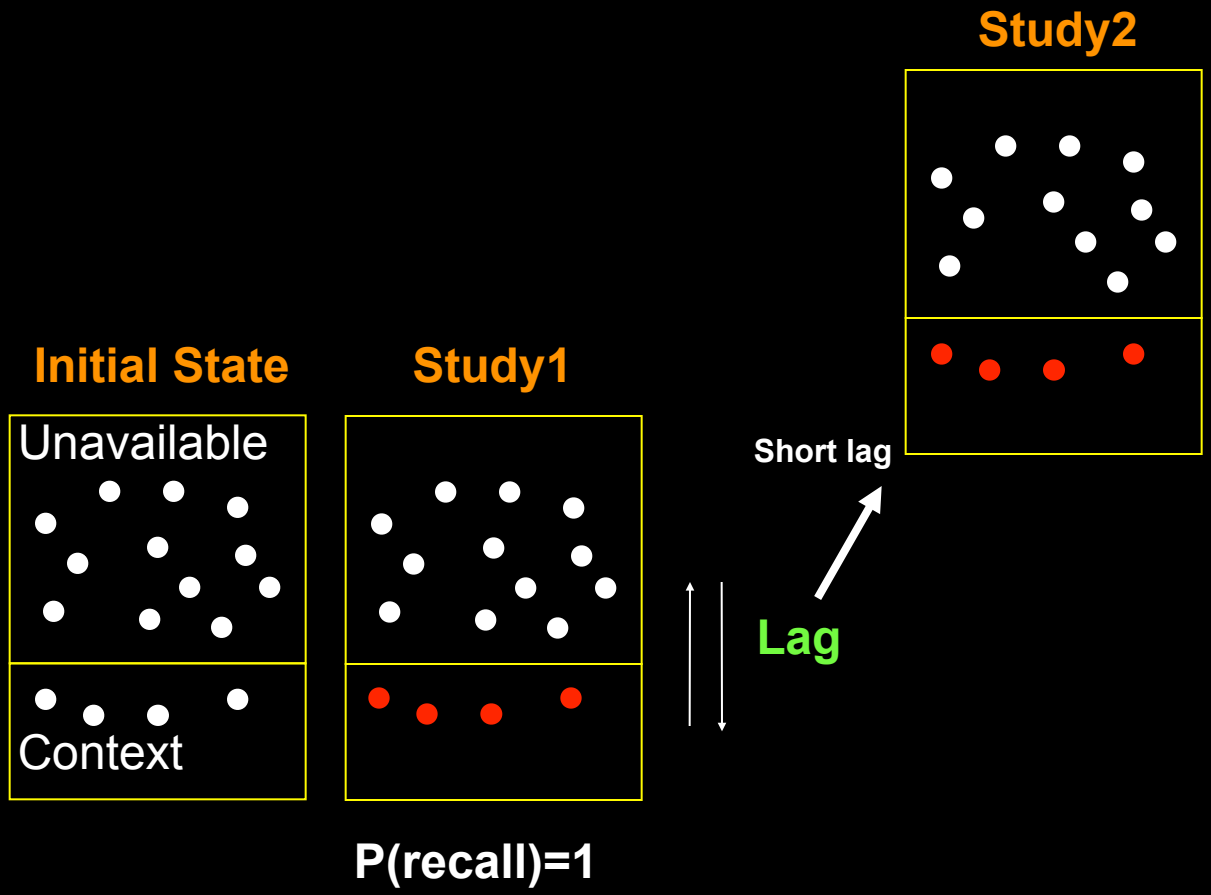
(Estes, 1955)

Stimulus Sampling Theory & Spacing



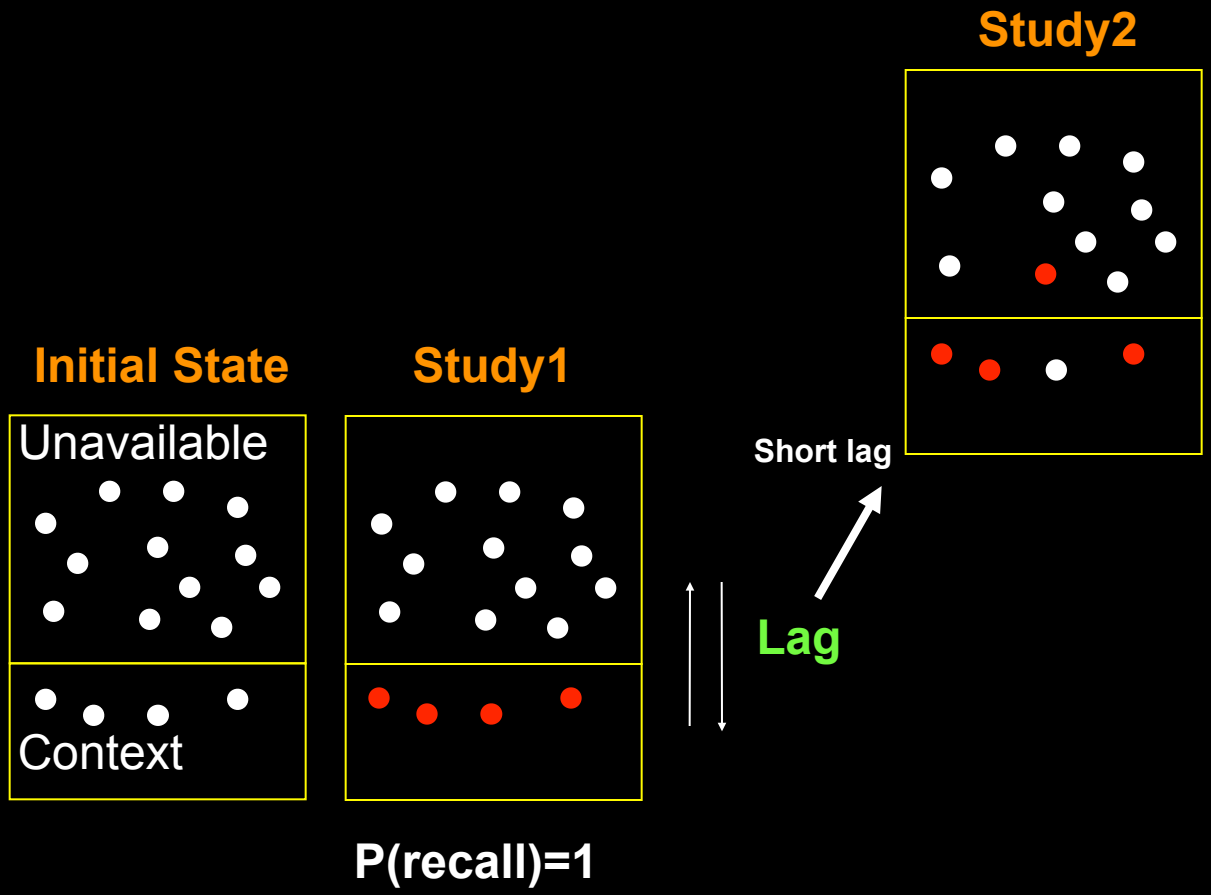
(Estes, 1955)

Stimulus Sampling Theory & Spacing



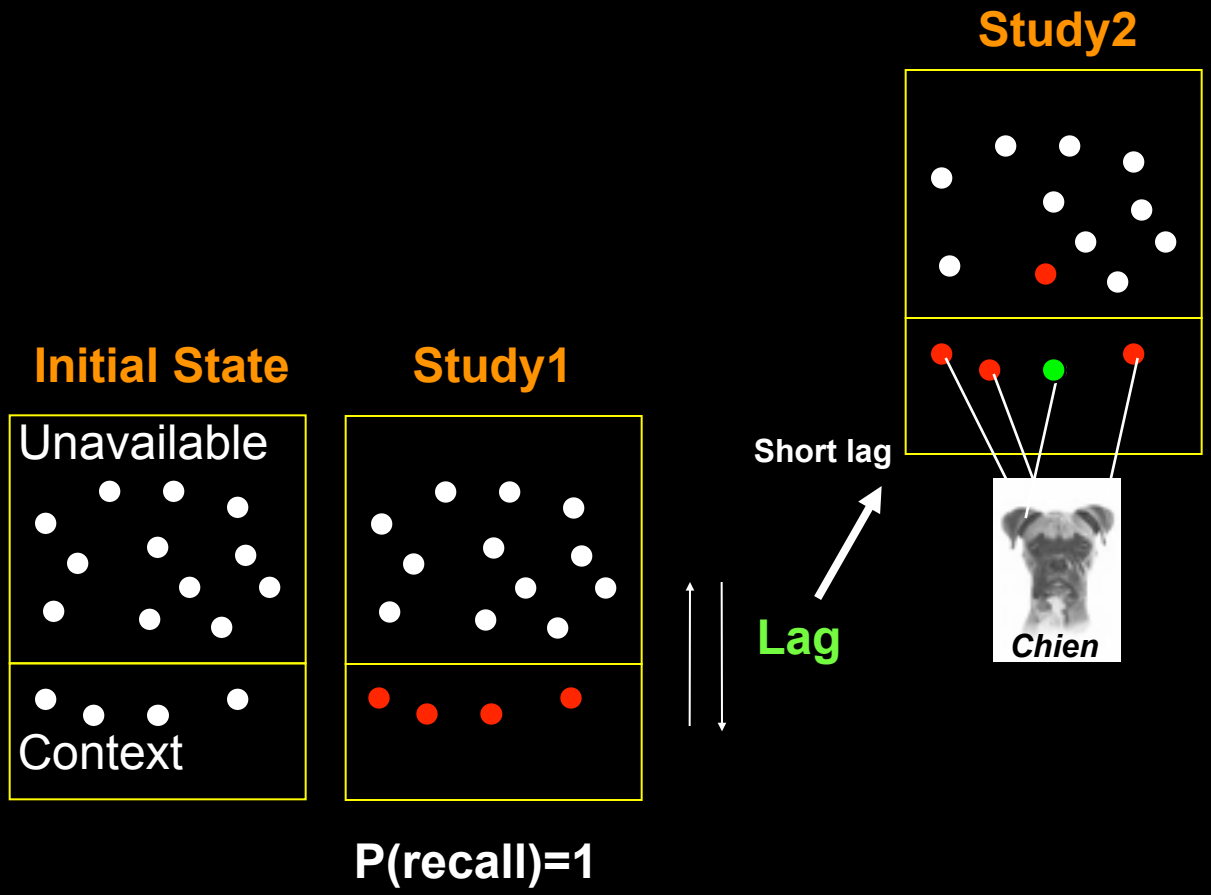
(Estes, 1955)

Stimulus Sampling Theory & Spacing



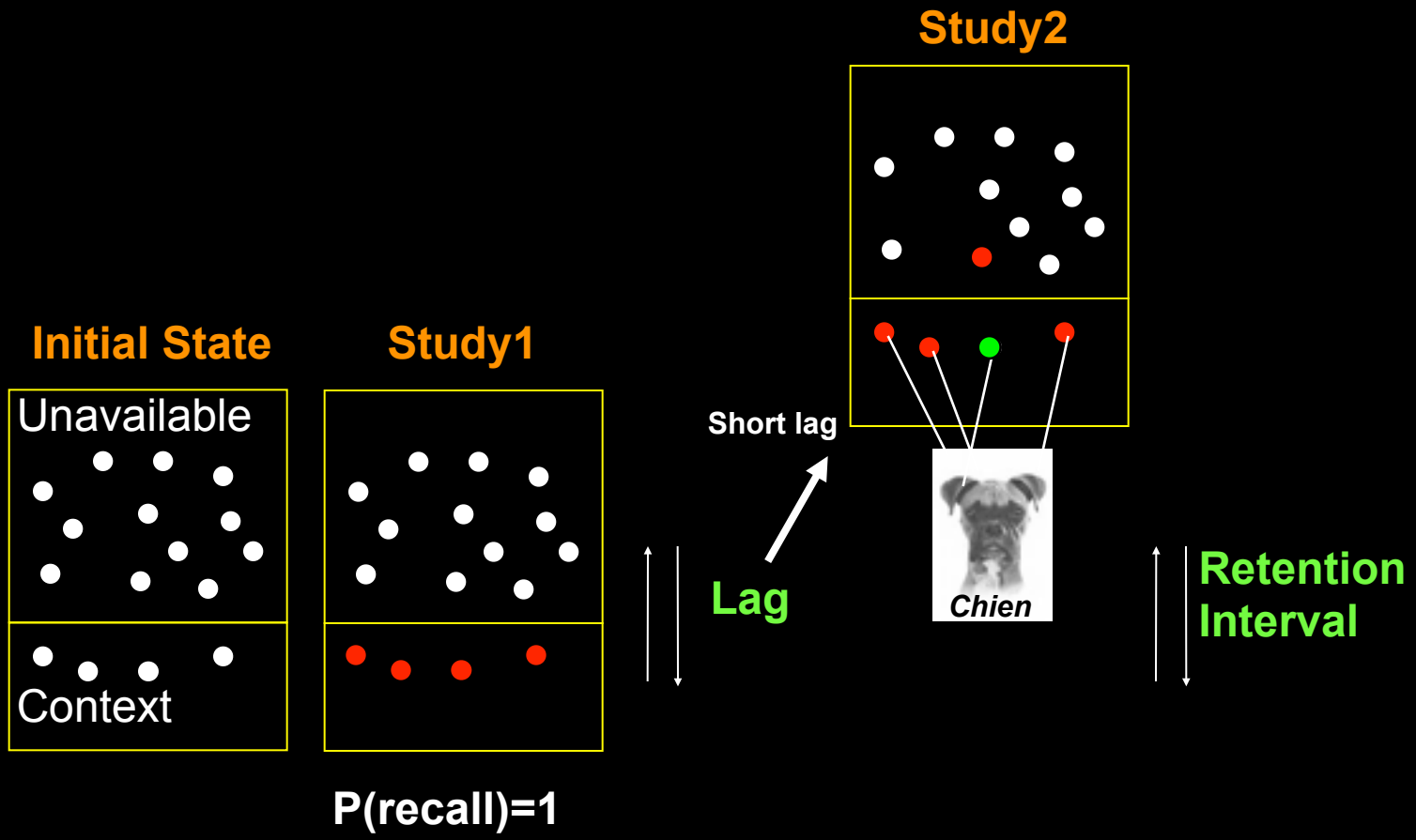
(Estes, 1955)

Stimulus Sampling Theory & Spacing



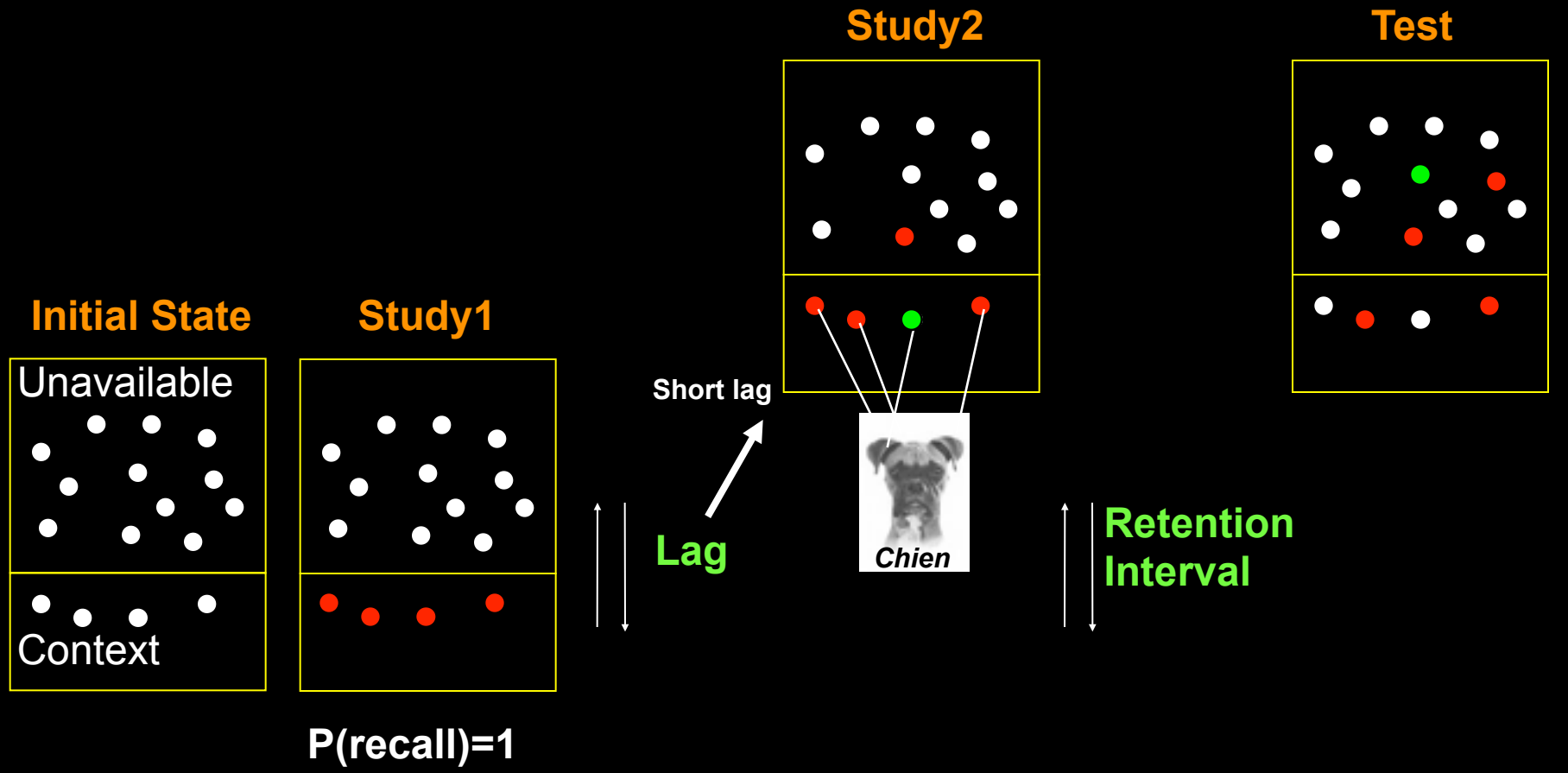
(Estes, 1955)

Stimulus Sampling Theory & Spacing



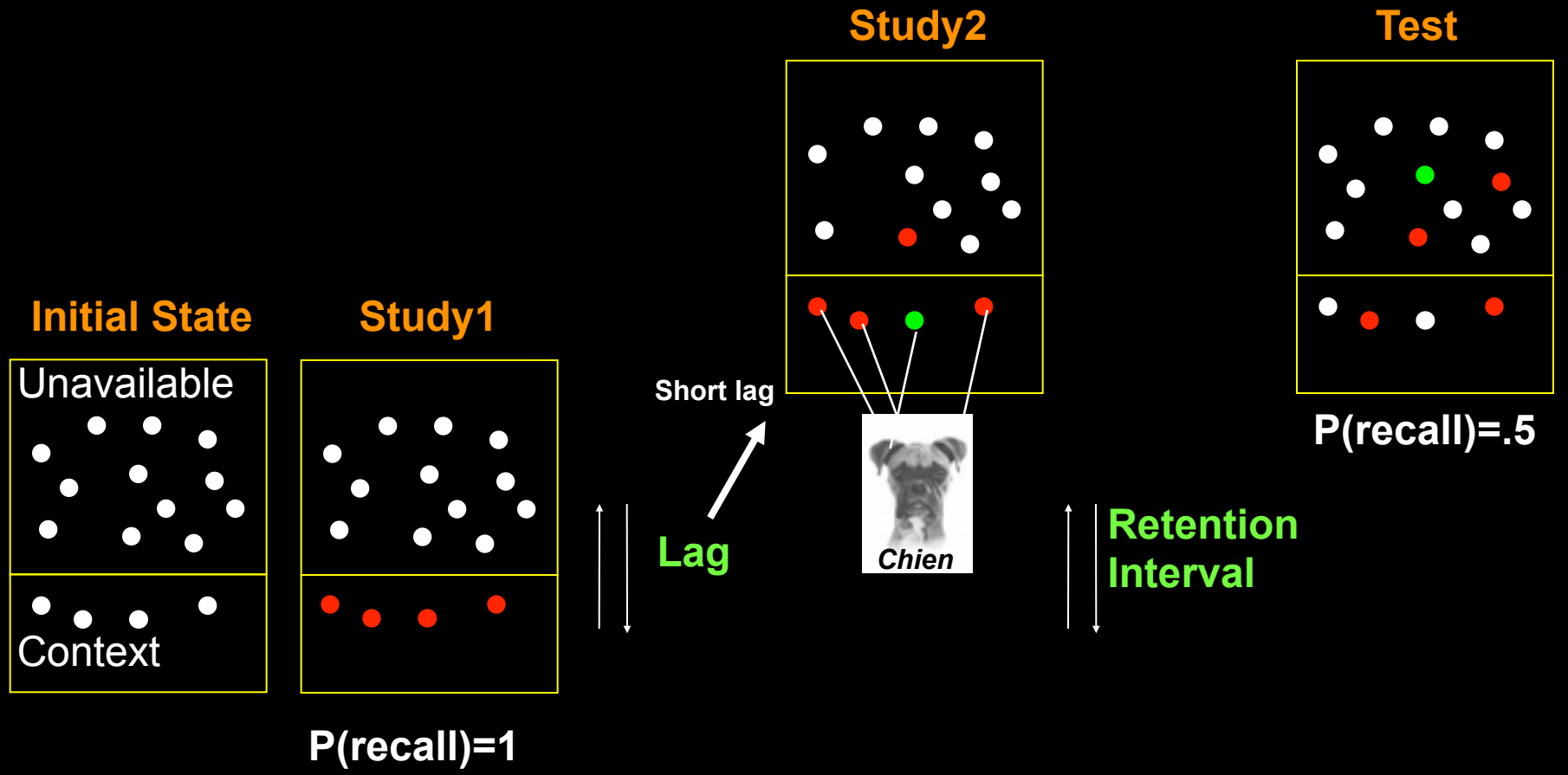
(Estes, 1955)

Stimulus Sampling Theory & Spacing



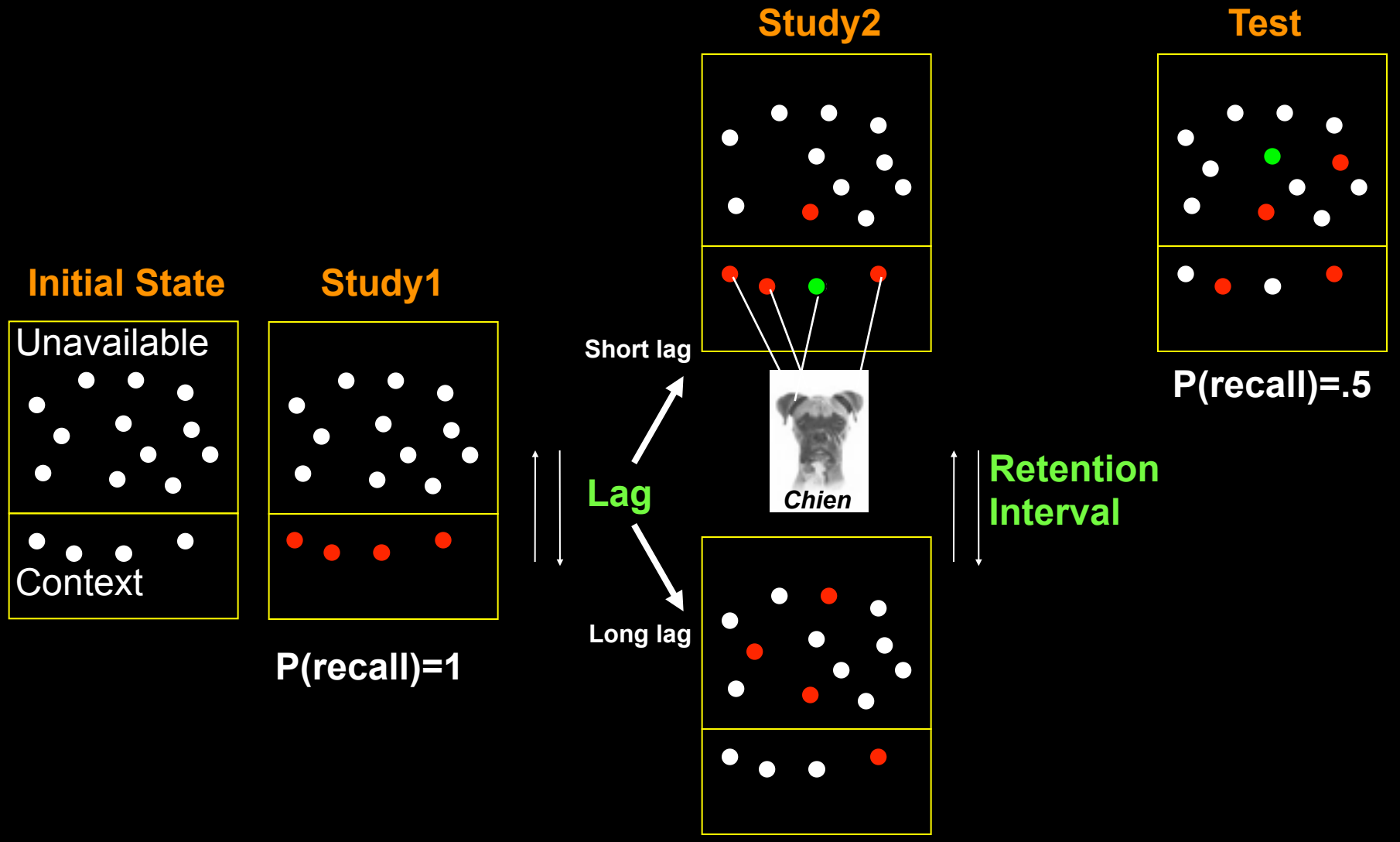
(Estes, 1955)

Stimulus Sampling Theory & Spacing



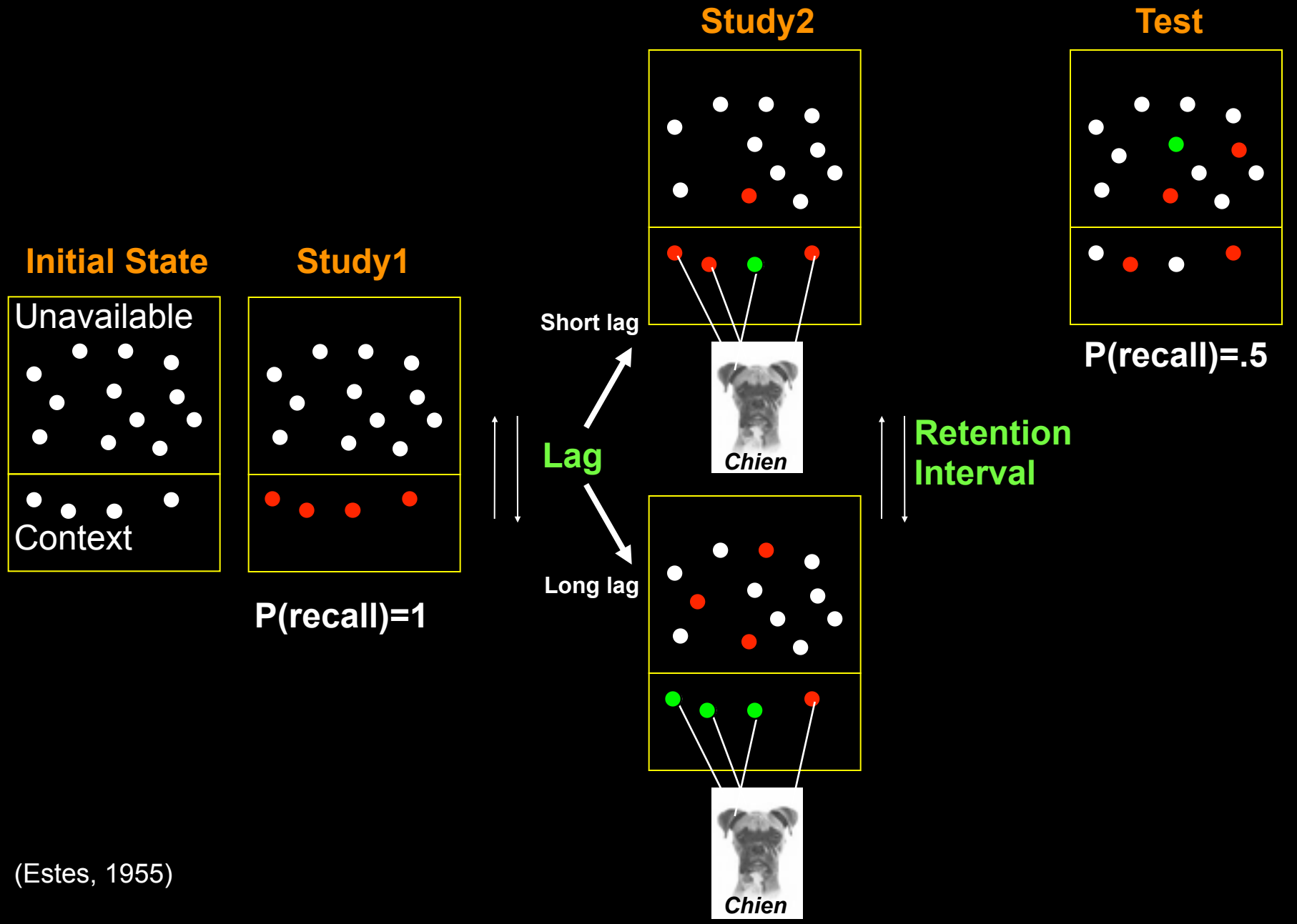
(Estes, 1955)

Stimulus Sampling Theory & Spacing



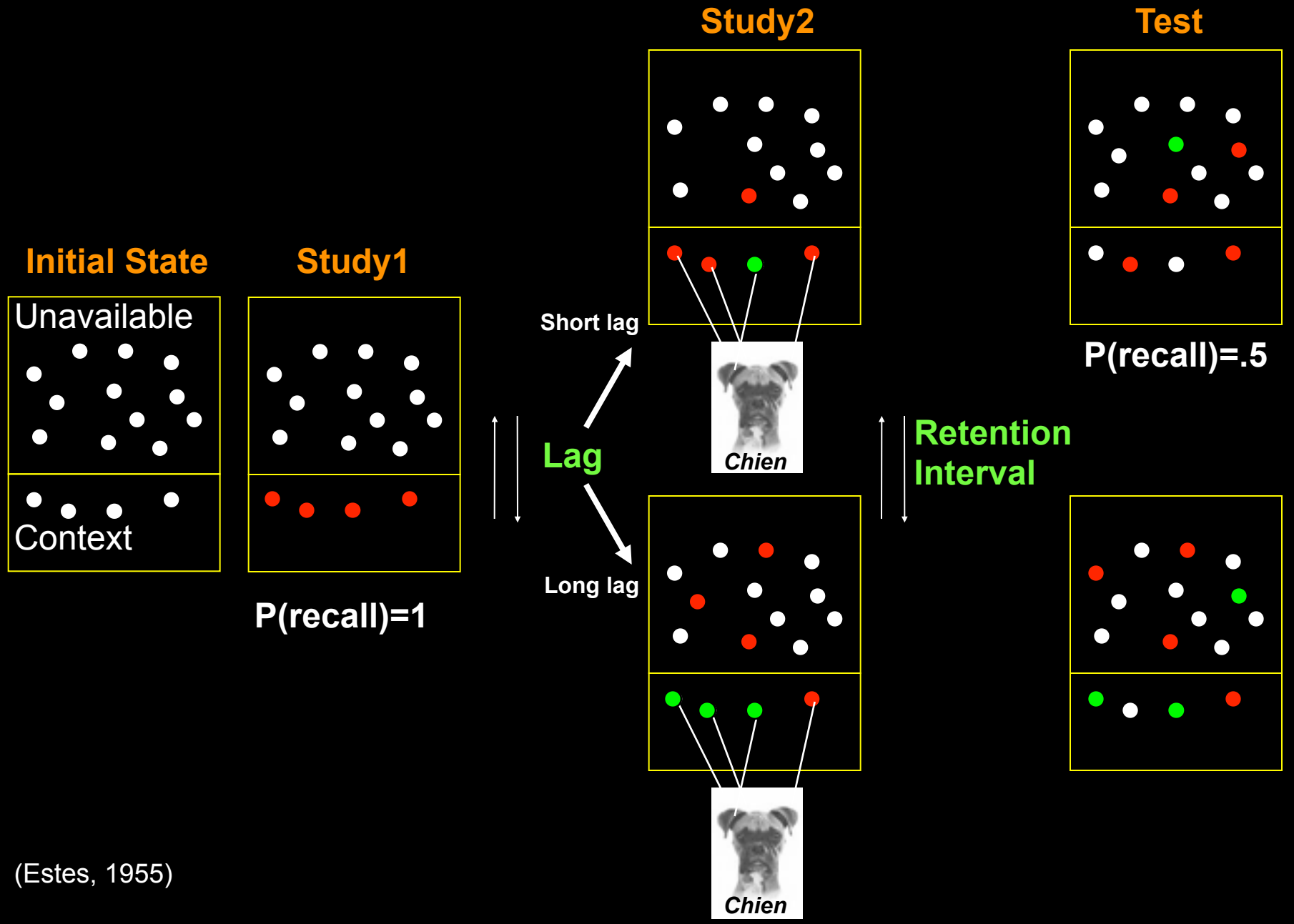
(Estes, 1955)

Stimulus Sampling Theory & Spacing



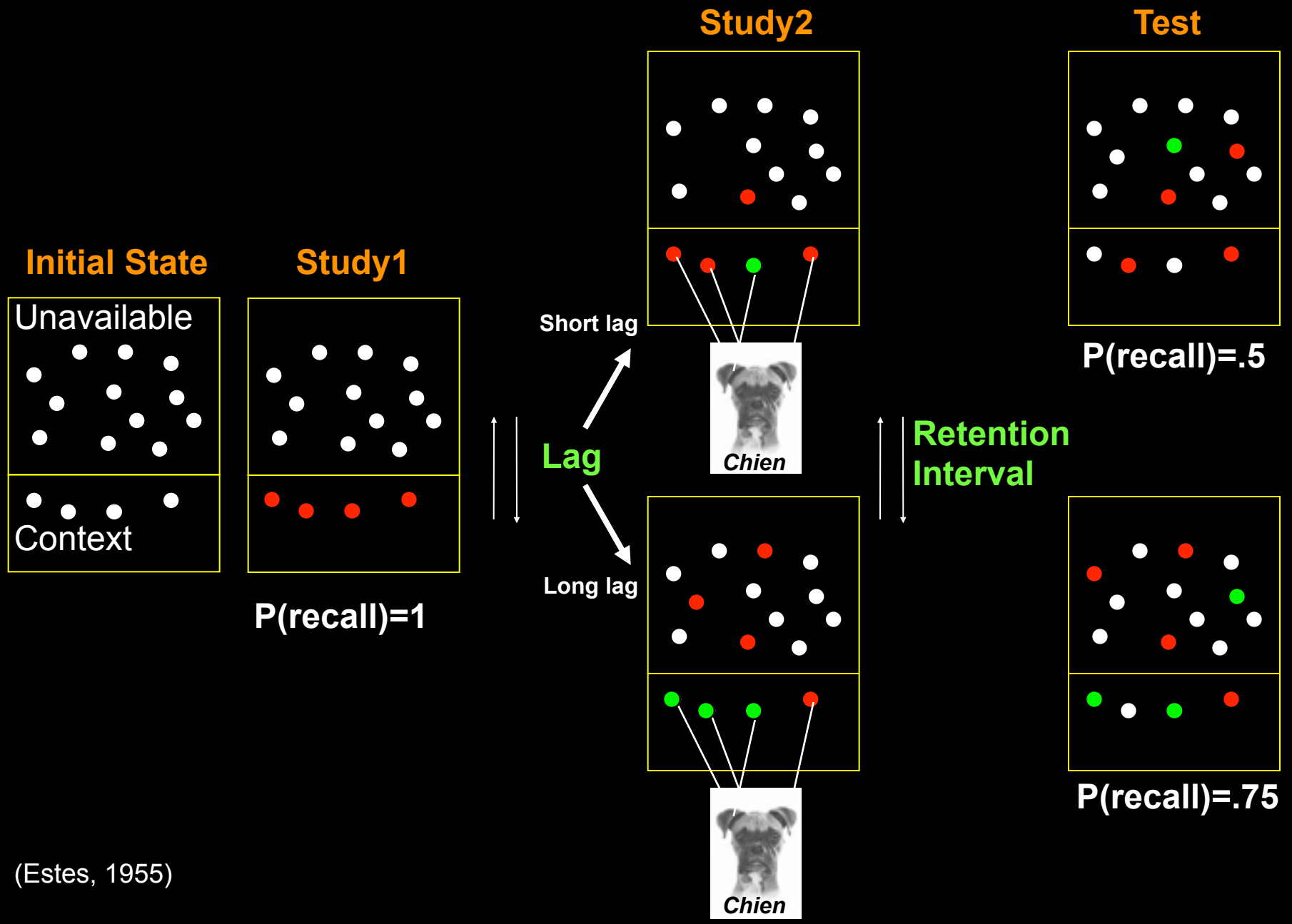
(Estes, 1955)

Stimulus Sampling Theory & Spacing



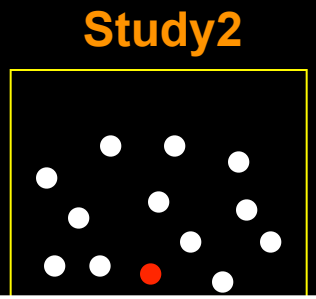
(Estes, 1955)

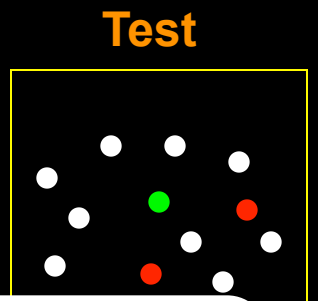
Stimulus Sampling Theory & Spacing



(Estes, 1955)

Stimulus Sampling Theory & Spacing





- Episodic memory is *associative*
  - binding of items to context
- Episodic retrieval is *cue dependent*
  - probability of remembering partly depends on the cues used to probe memory
- *Context* plays a powerful role in episodic memory

P(recall)=.75

(Estes, 1955)

Summary: Optimal Learning Strategies

- Attend to the information
  - minimize distractions
- Attend to the attributes of the information that you expect you will need to remember in the future
  - typically the meaning of events
  - relate new information to other things you know
- Practice retrieving the information from memory
- Distribute your study episodes/retrieval practices across time