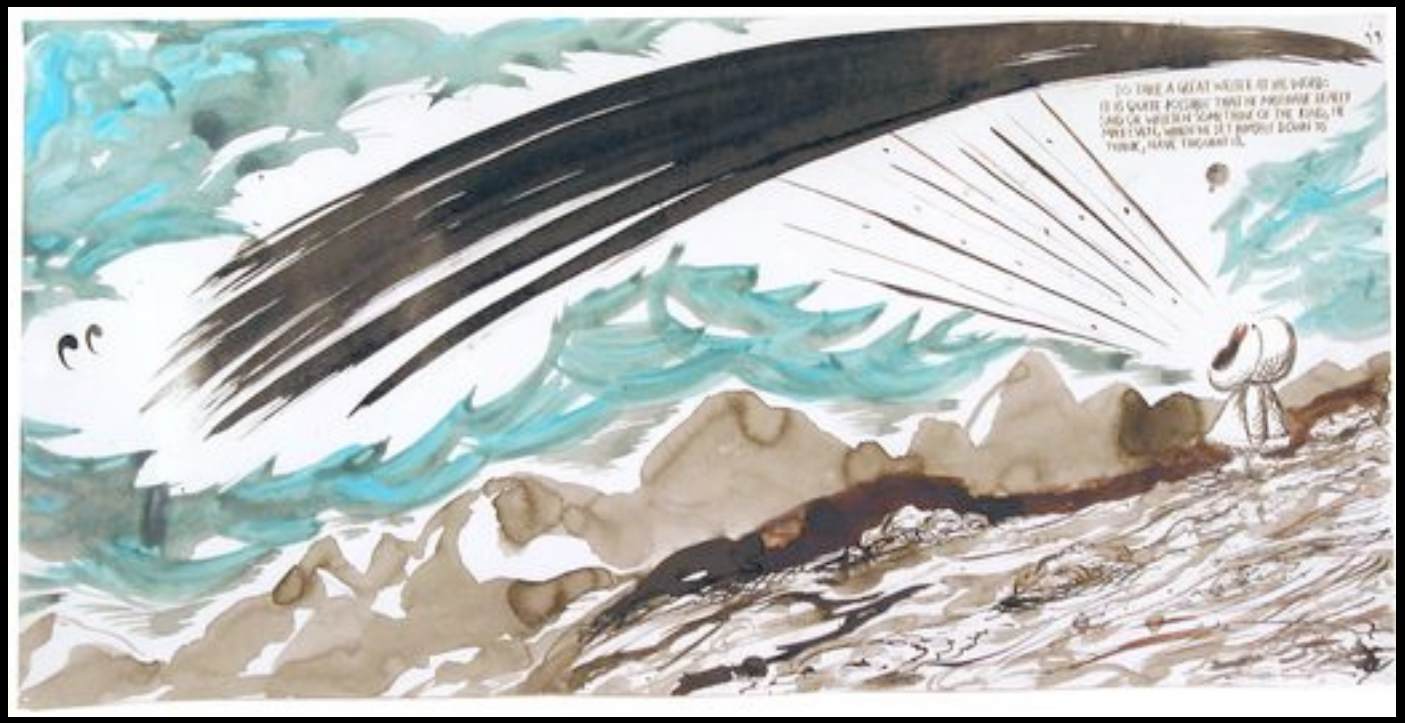
Outline

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

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: process perceptual features of the stimulus
phonological: process stimulus via speech codes
semantic: process the meaning of the stimulus

Deep (conceptual aspects)

Depth of Processing

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Encoding = incidental byproduct of active stimulus processing

Depth of Processing

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Shallow (sensory aspects)

perceptual: process perceptual features of the stimulus
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semantic: process the meaning of the stimulus

Deep (conceptual aspects)

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

Encoding = incidental byproduct of active stimulus processing

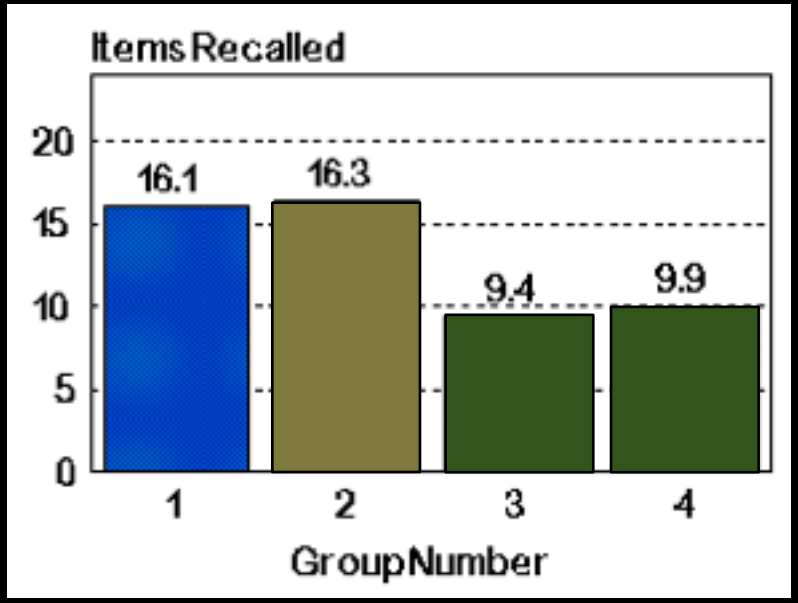
DoP Effect: Hyde & Jenkins (1968)

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

- 1) Intentionally commit words to memory

D
- 2) Judge pleasantness of words

S
- 3) Judge whether there is an “e” in the word
- 4) Judge how many letters are in the word



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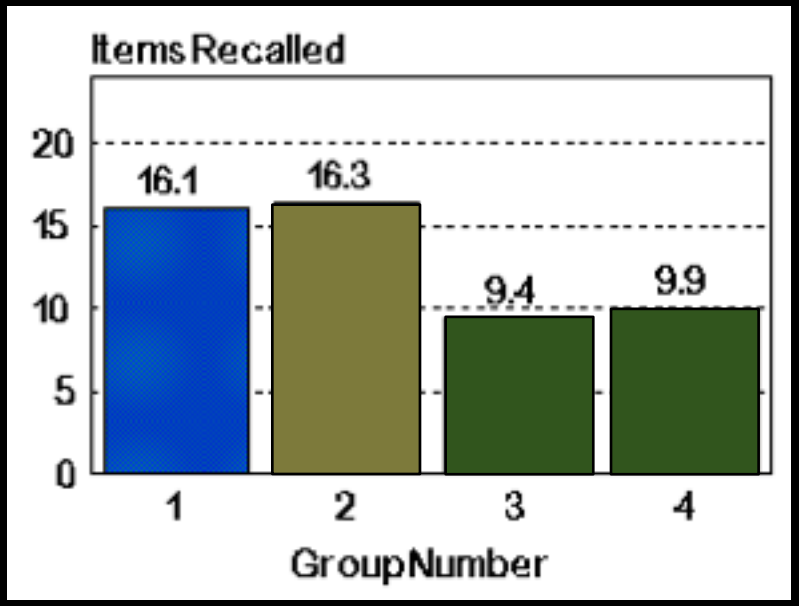
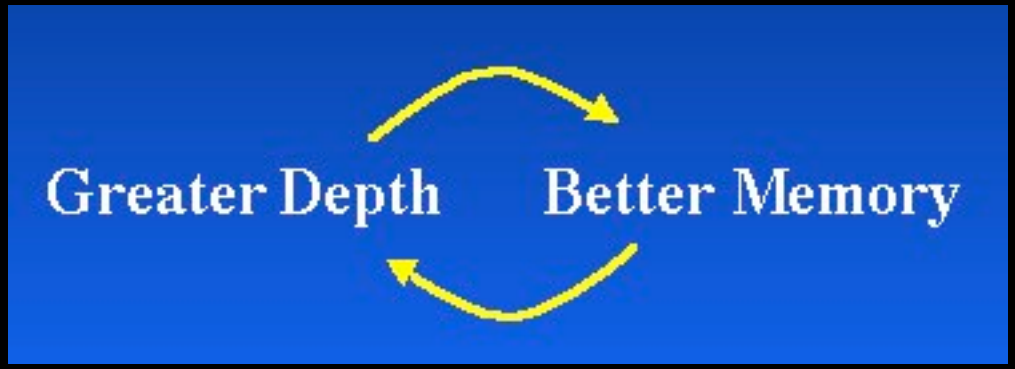


- Memory was better after Deep vs. Shallow encoding

- 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?

- Alternative hypothesis: 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

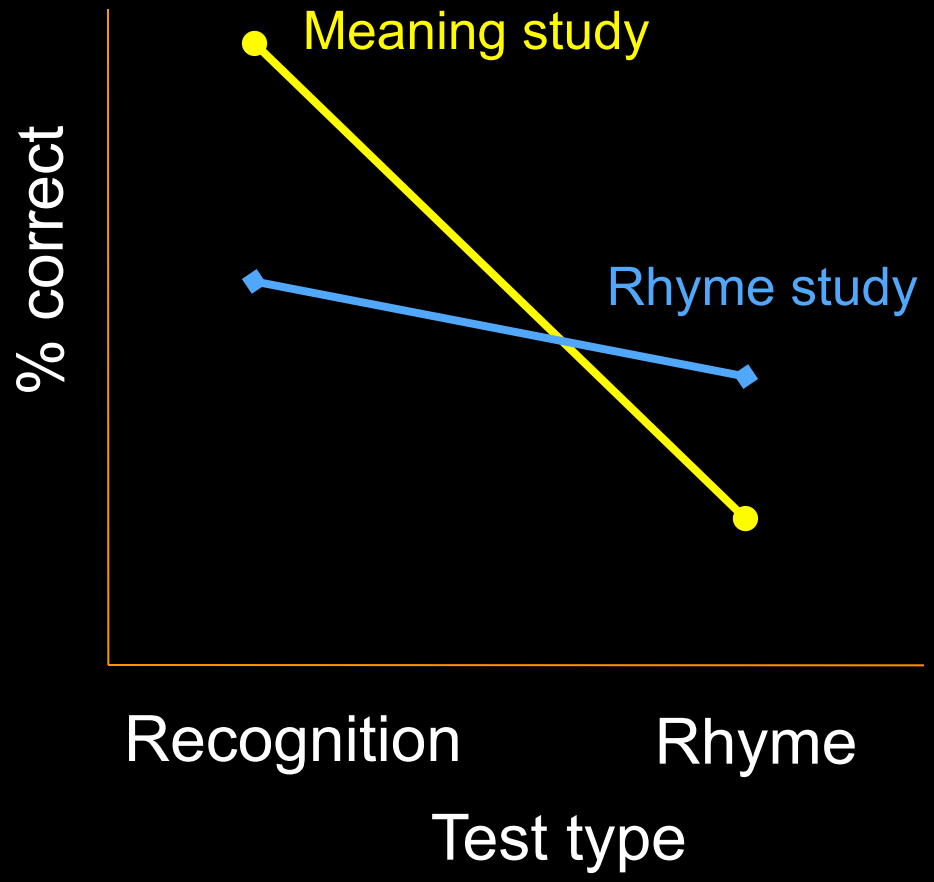
- In each case, they had to say whether a target word fit into the blank
- Meaning condition
  - The _____ was on the shelf
    - "book" - yes or no
- Phonology (rhyme) condition
  - _____ rhymes with fear
    - "spear" - yes or no

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 learn
  - Tests are the best way to learn and retain information
- Spaced practice

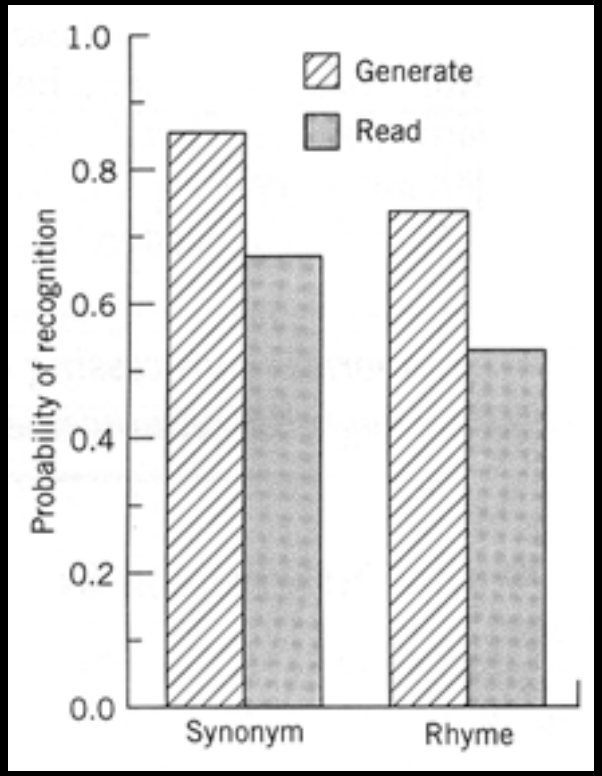
The Generation Effect

READ Conditions:

Synonym	Unhappy – SAD
Rhyme	Lad – SAD

GENERATE Conditions:

Synonym	Unhappy – S___?
Rhyme	Lad – S__?



Depth of Processing

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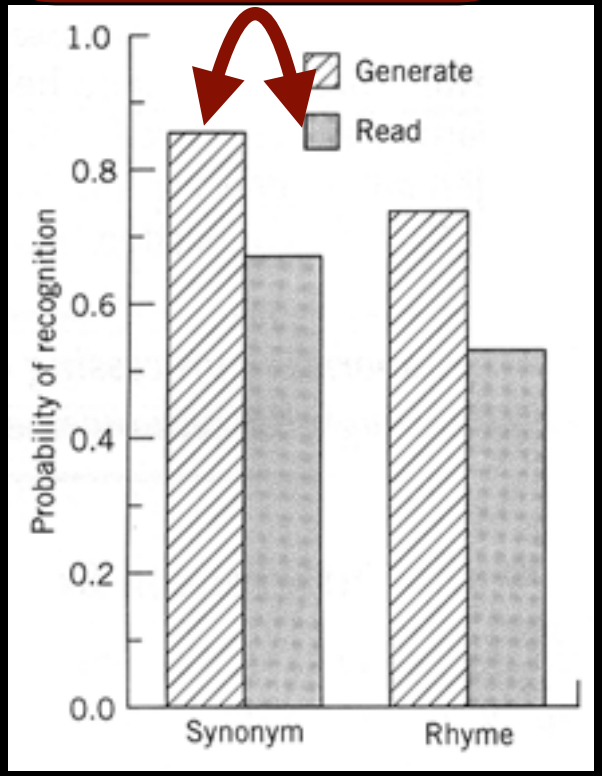

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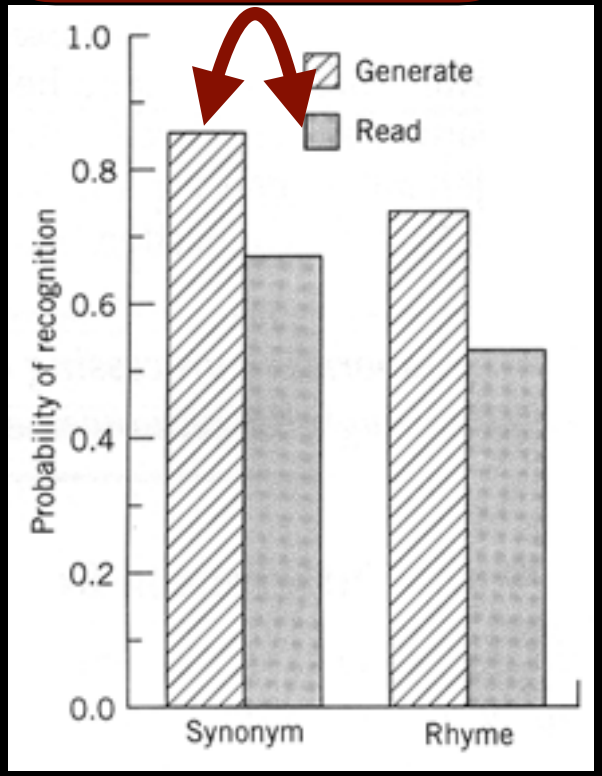

You are more likely to remember material if you generate it yourself, rather than simply being exposed to it

Depth of Processing

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

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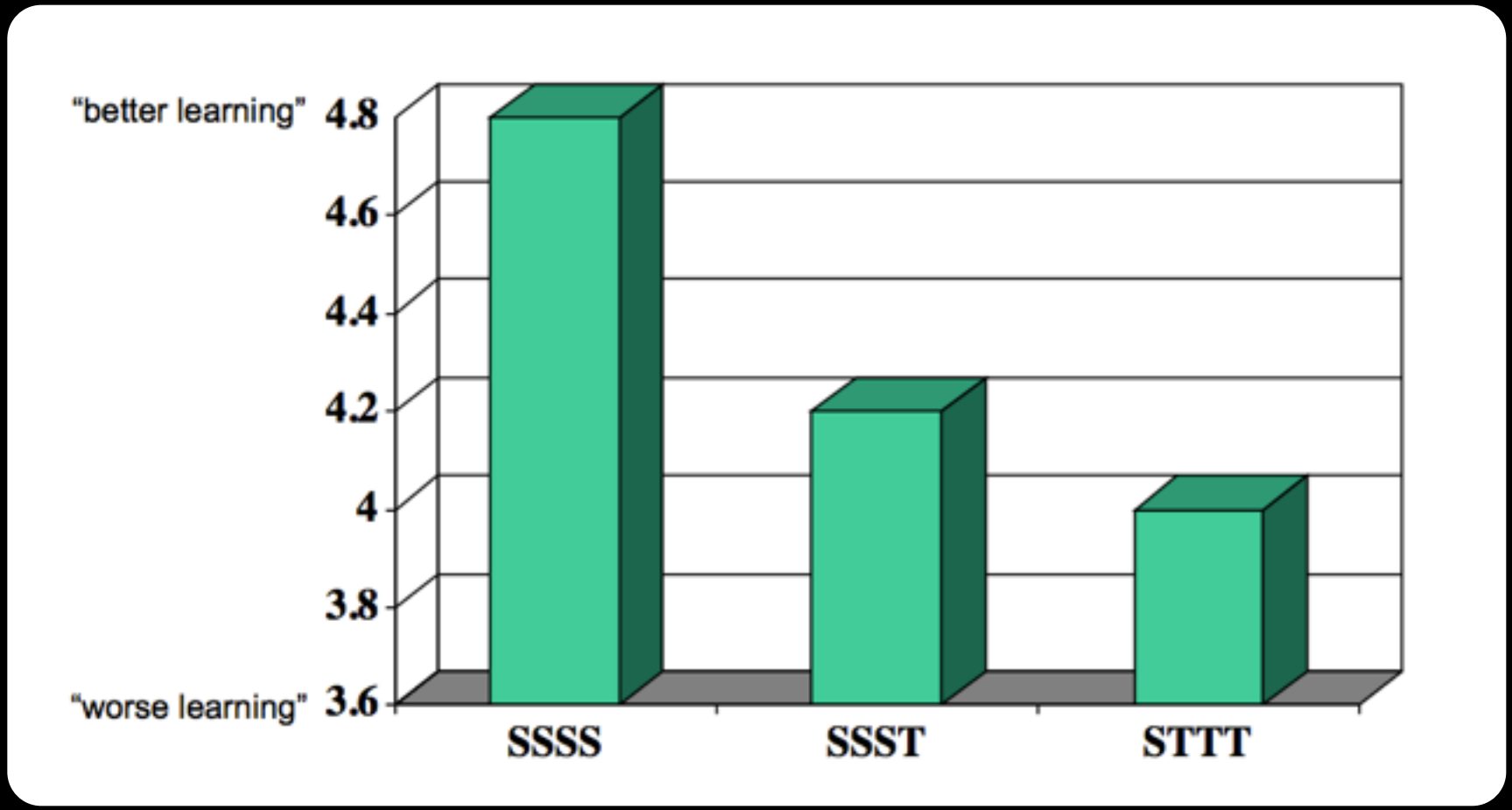
Critical measures

- Immediately asked how well they felt they had learned the material (*Judgment of Learning; JOL*)
- 5 min or 1 week later, then tested on how well they retained the ideas from the passage

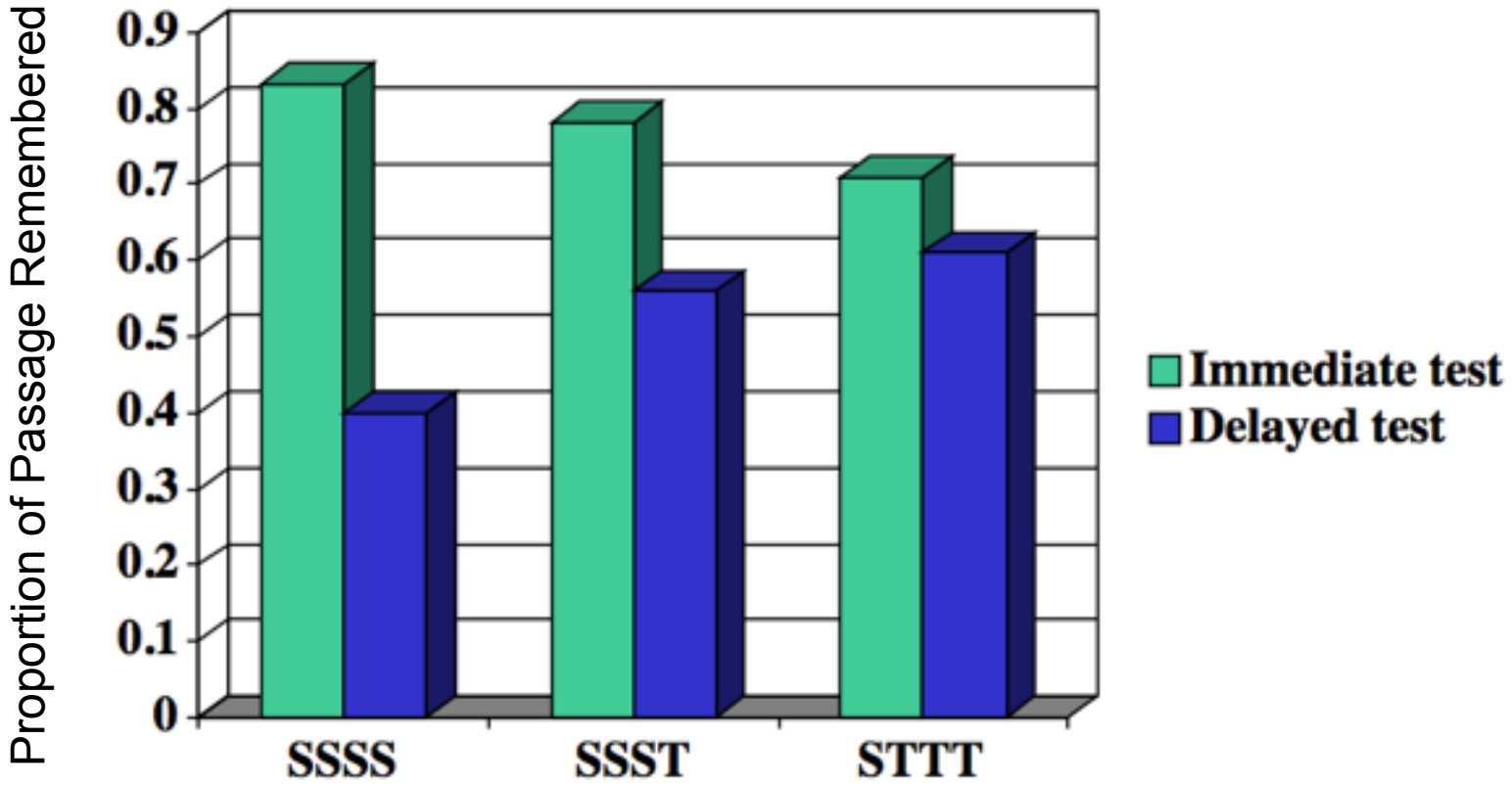
Judgments of Learning (JOL)



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

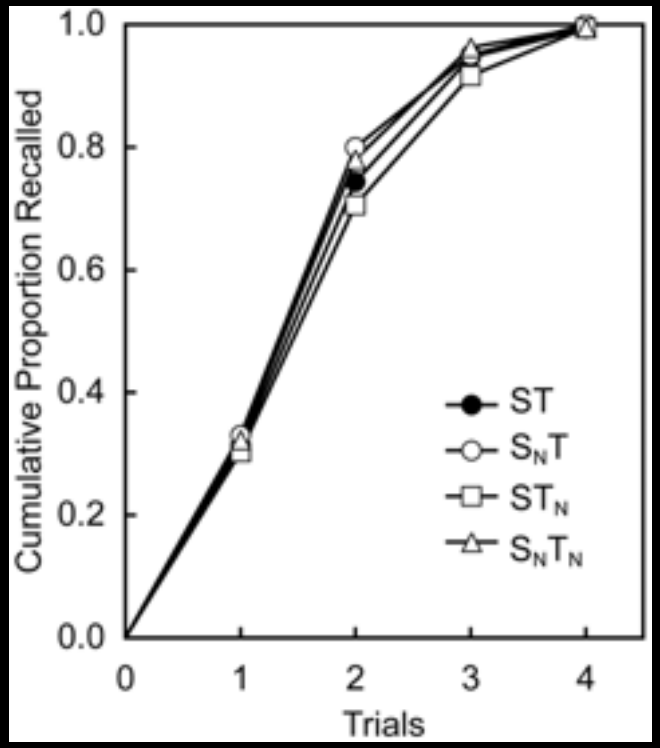
Roediger & Karpicke, 2006

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



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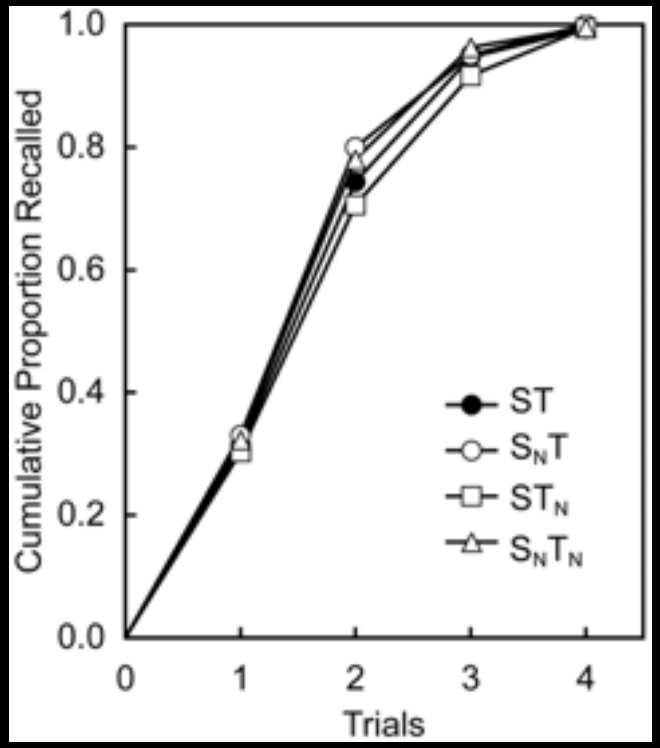
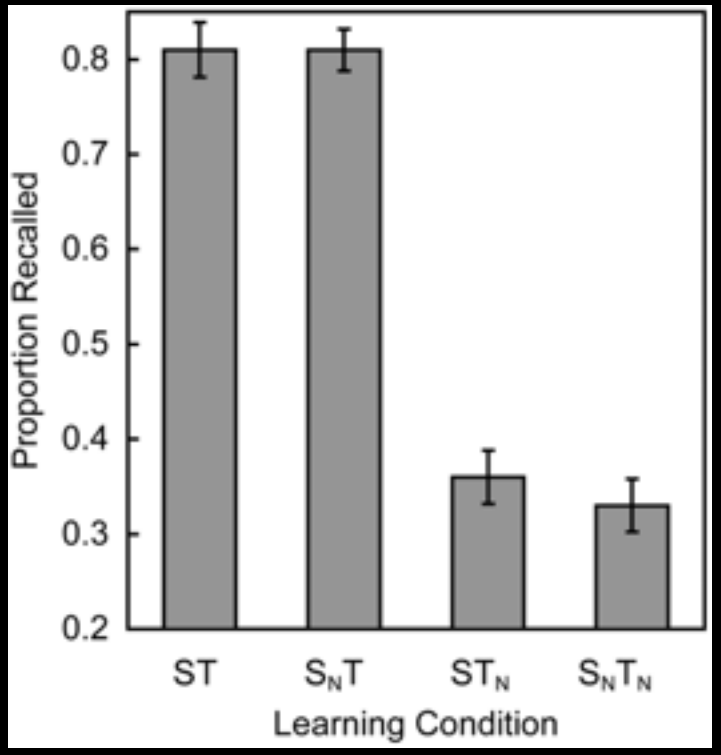


Test after 1-week delay



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

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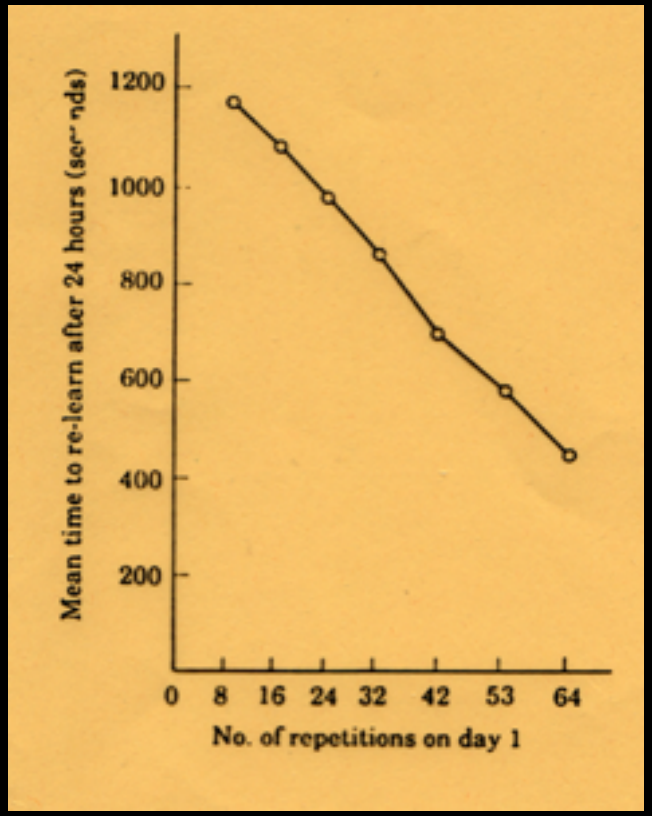
Ebbinghaus on Repetition

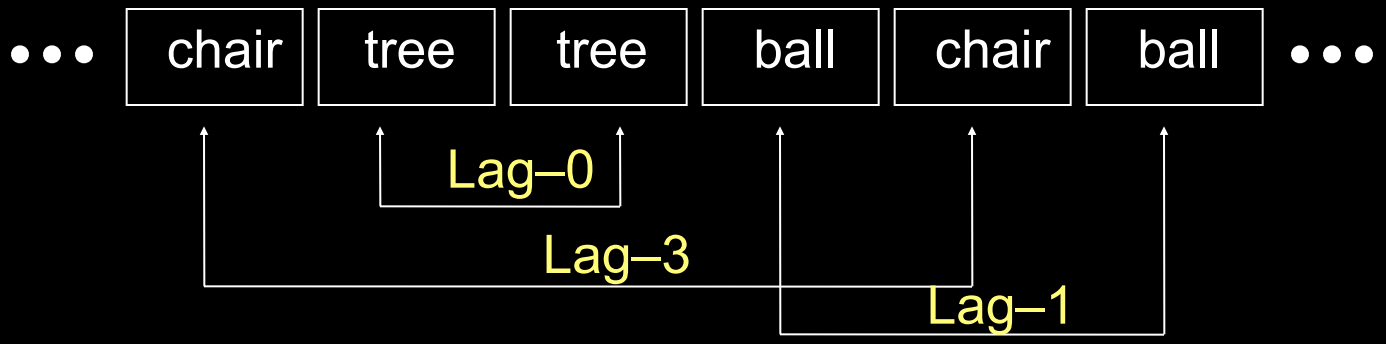
- Found that repeatedly studying stimuli reduced forgetting
  - The more repetitions, the better his memory performance



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)



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

Foot Shoe (*Read*)

OR

Foot S - - e *(Generate)*

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

The Spacing Effect

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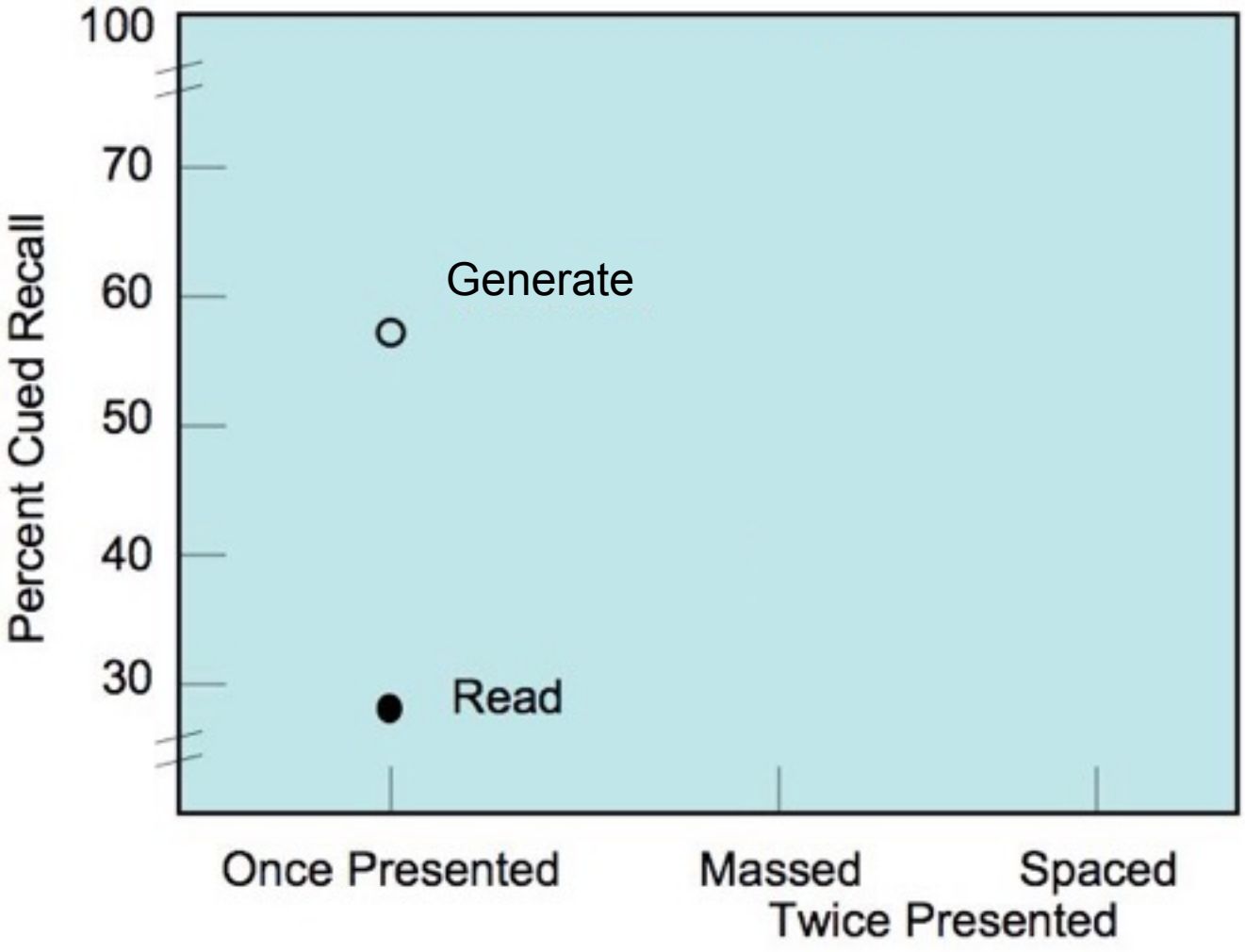
Test Phase (Cued Recall)

Foot ????

Jacoby (1978)


100
70
60
50
40
30
Percent Cued Recall
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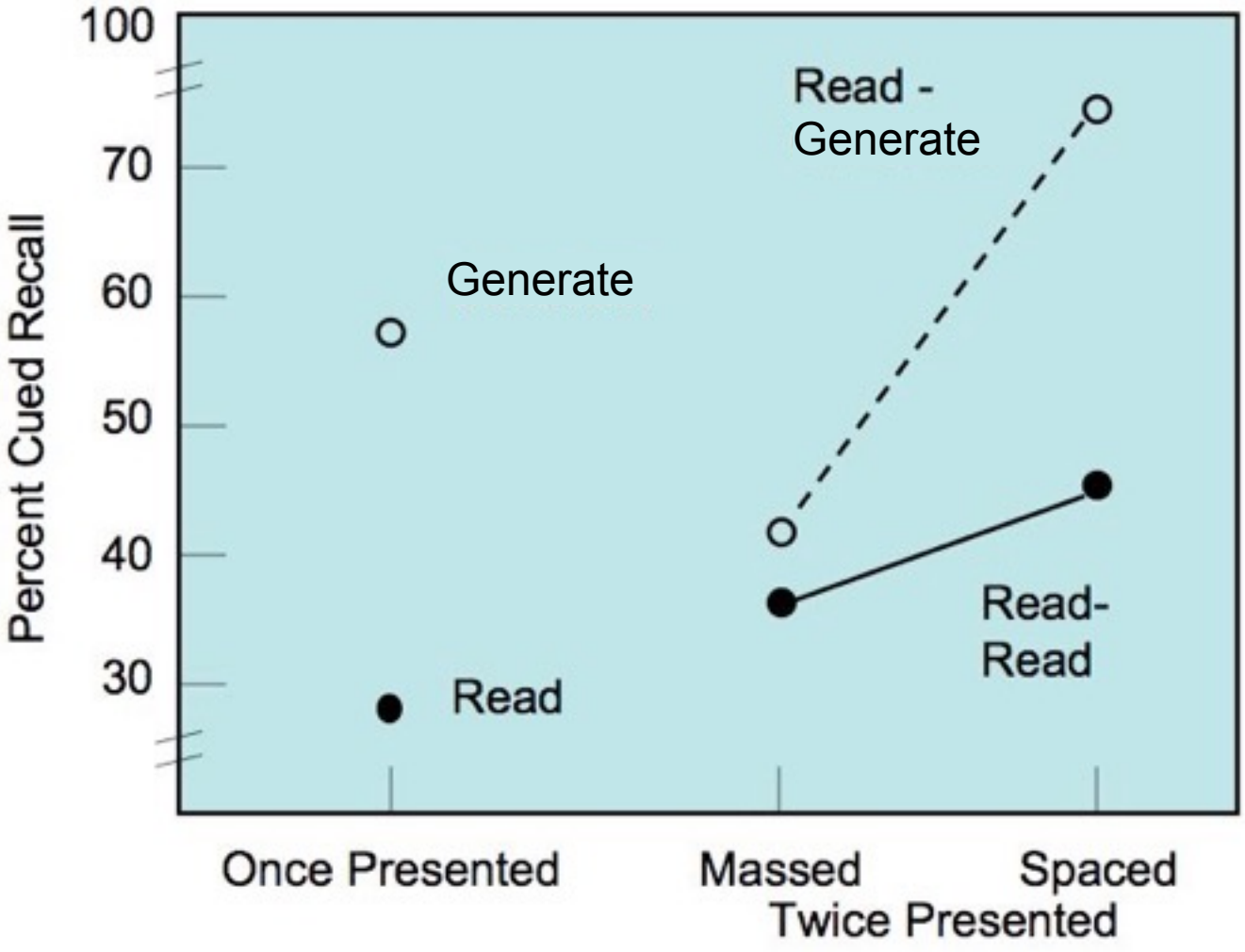
Jacoby (1978)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Generate
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Understanding the Spacing Effect

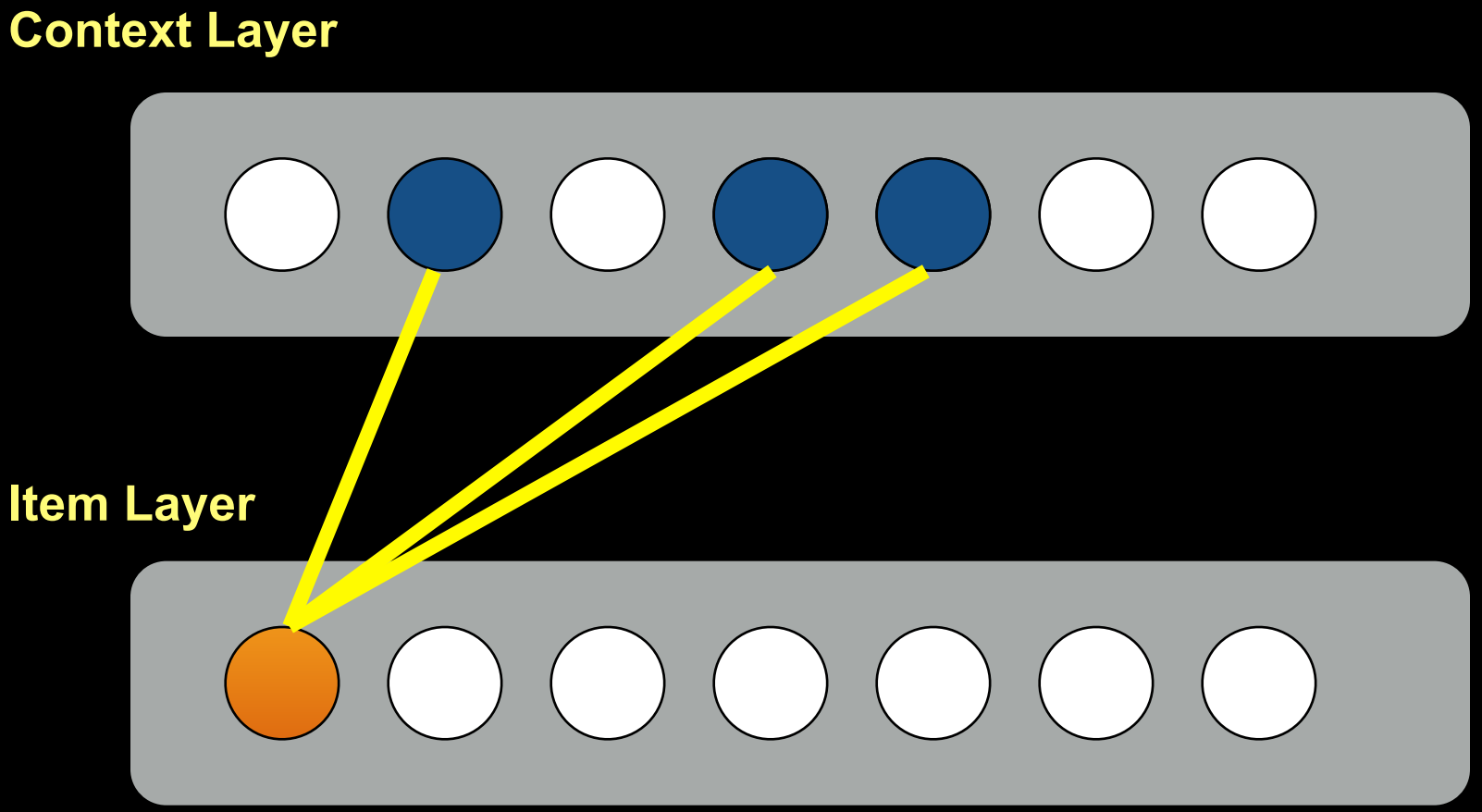
Deficient processing: during massed practice, repeated occurrences of an item are not processed fully

- 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 or thinking about the material
- variability may derive from context fluctuations across time (Estes' stimulus sampling theory; see Fig 1.8)
- variable encoding improves retrieval because one has more cues to use when trying to remember

Episodic Encoding:
Binding of Items and Context



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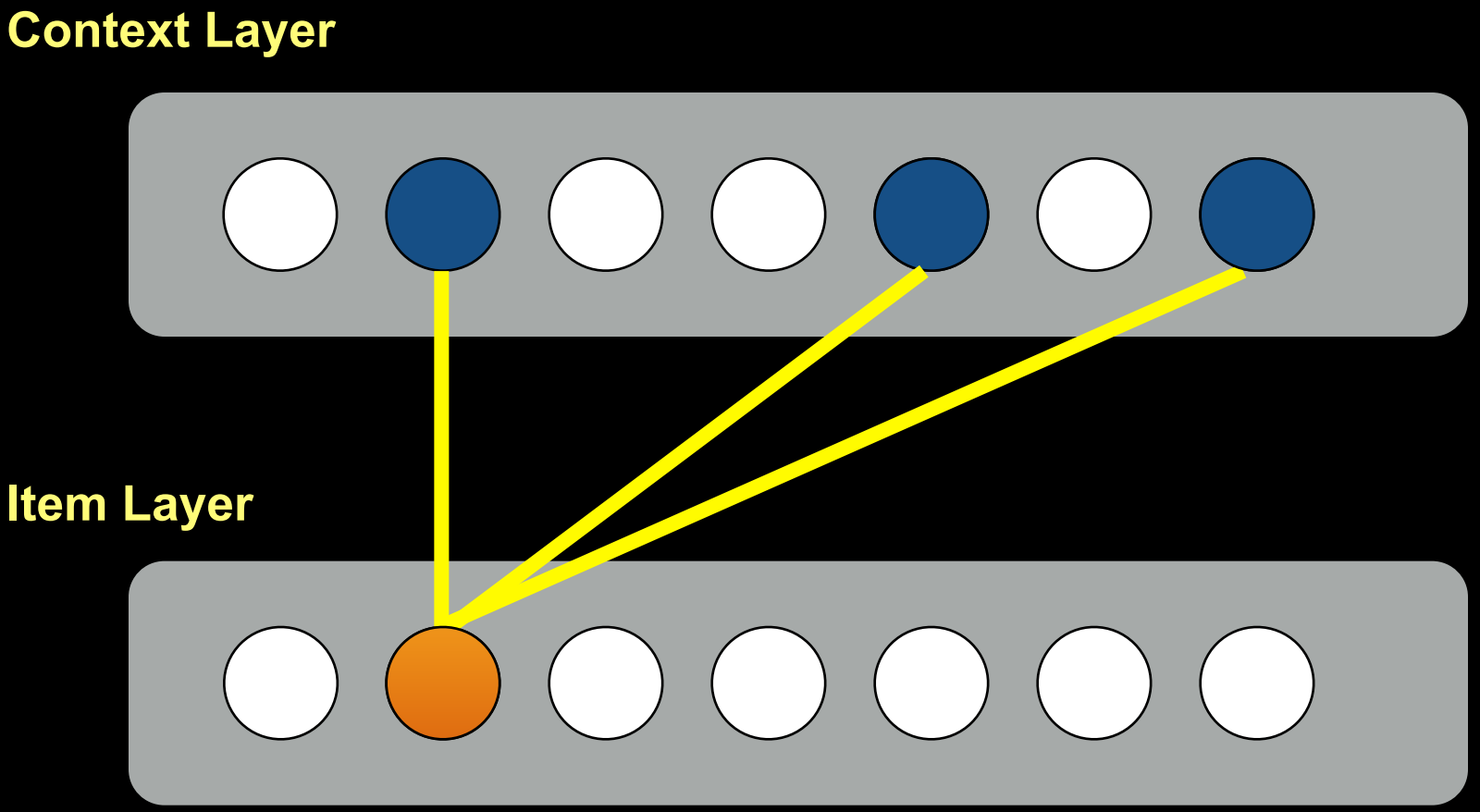

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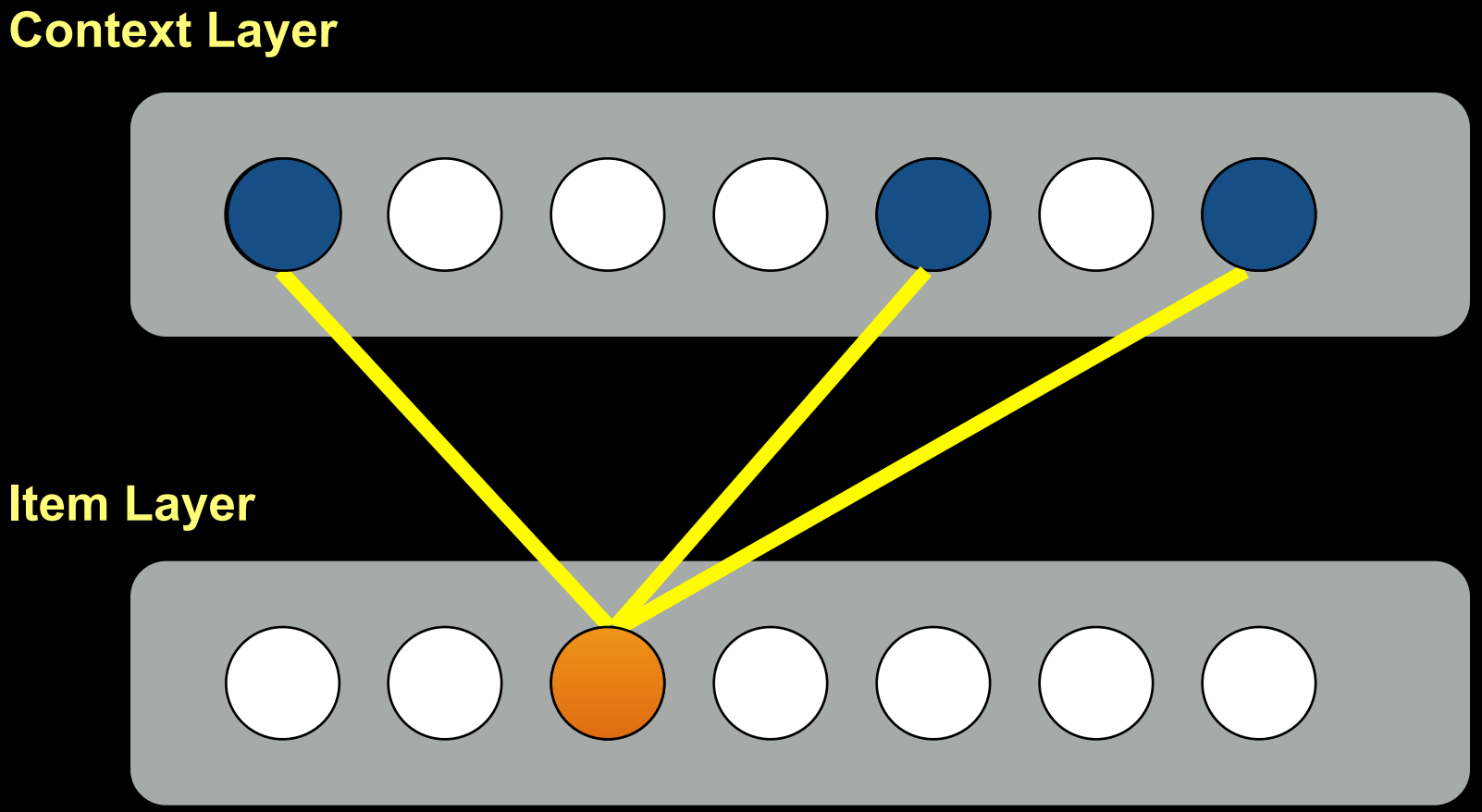

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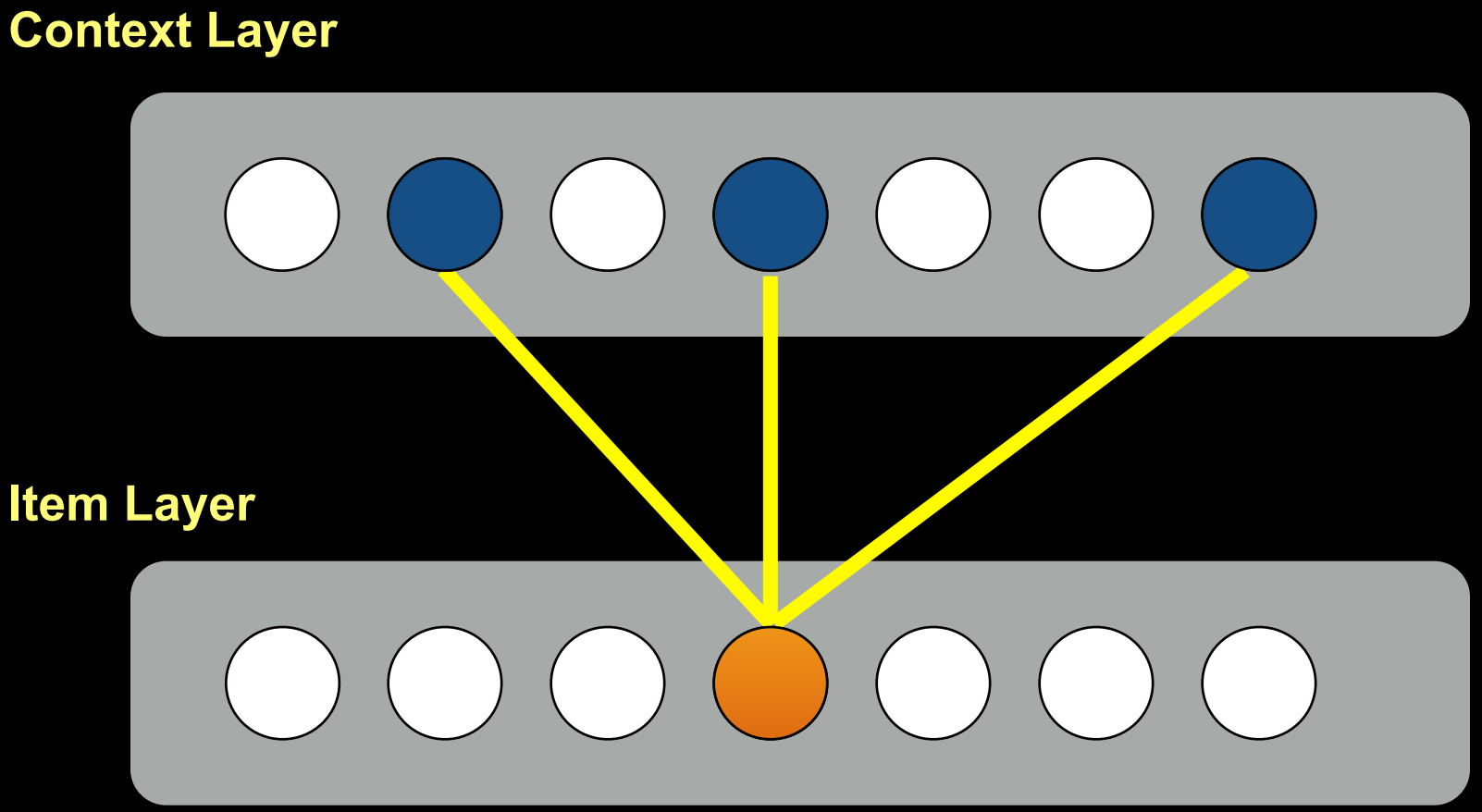

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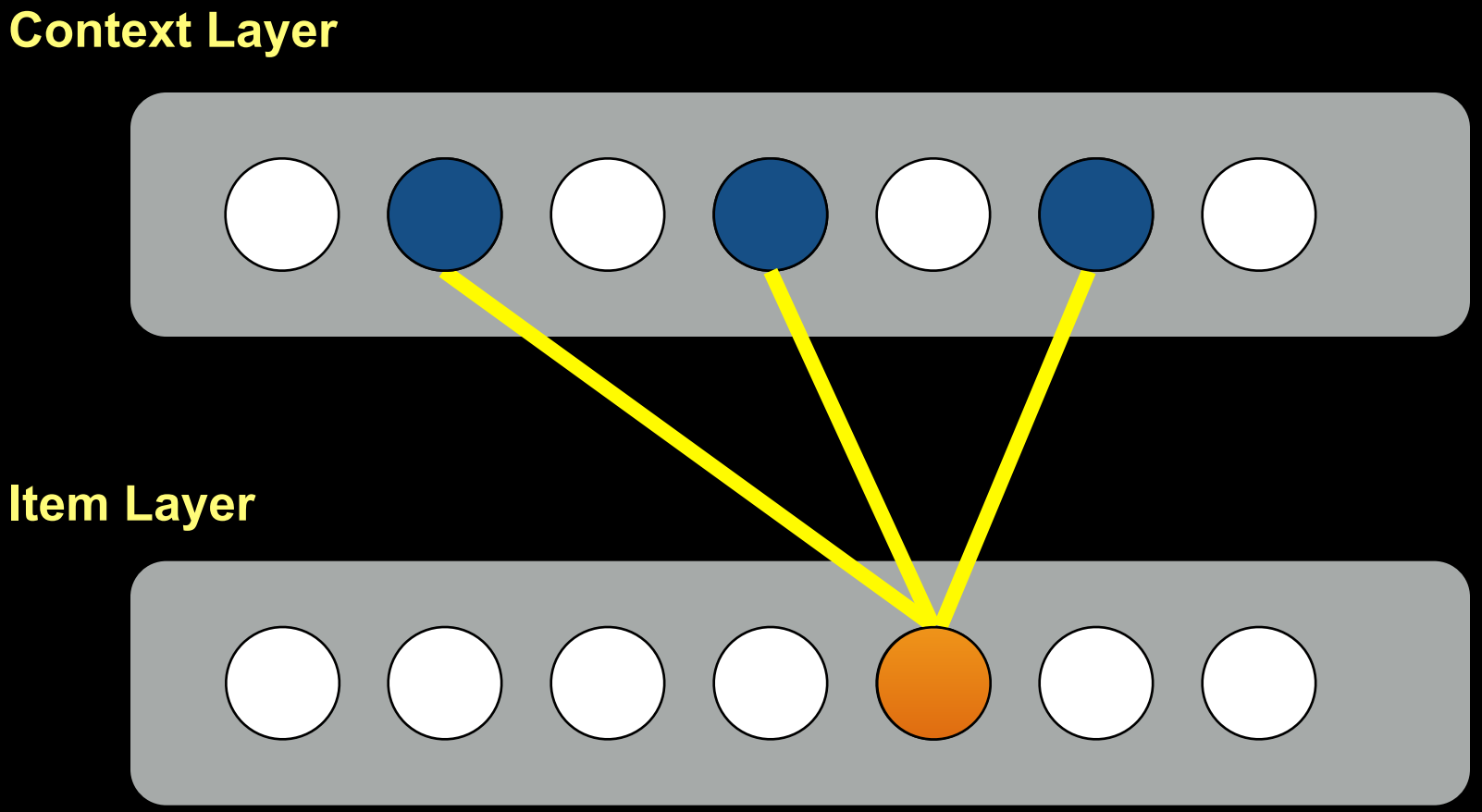

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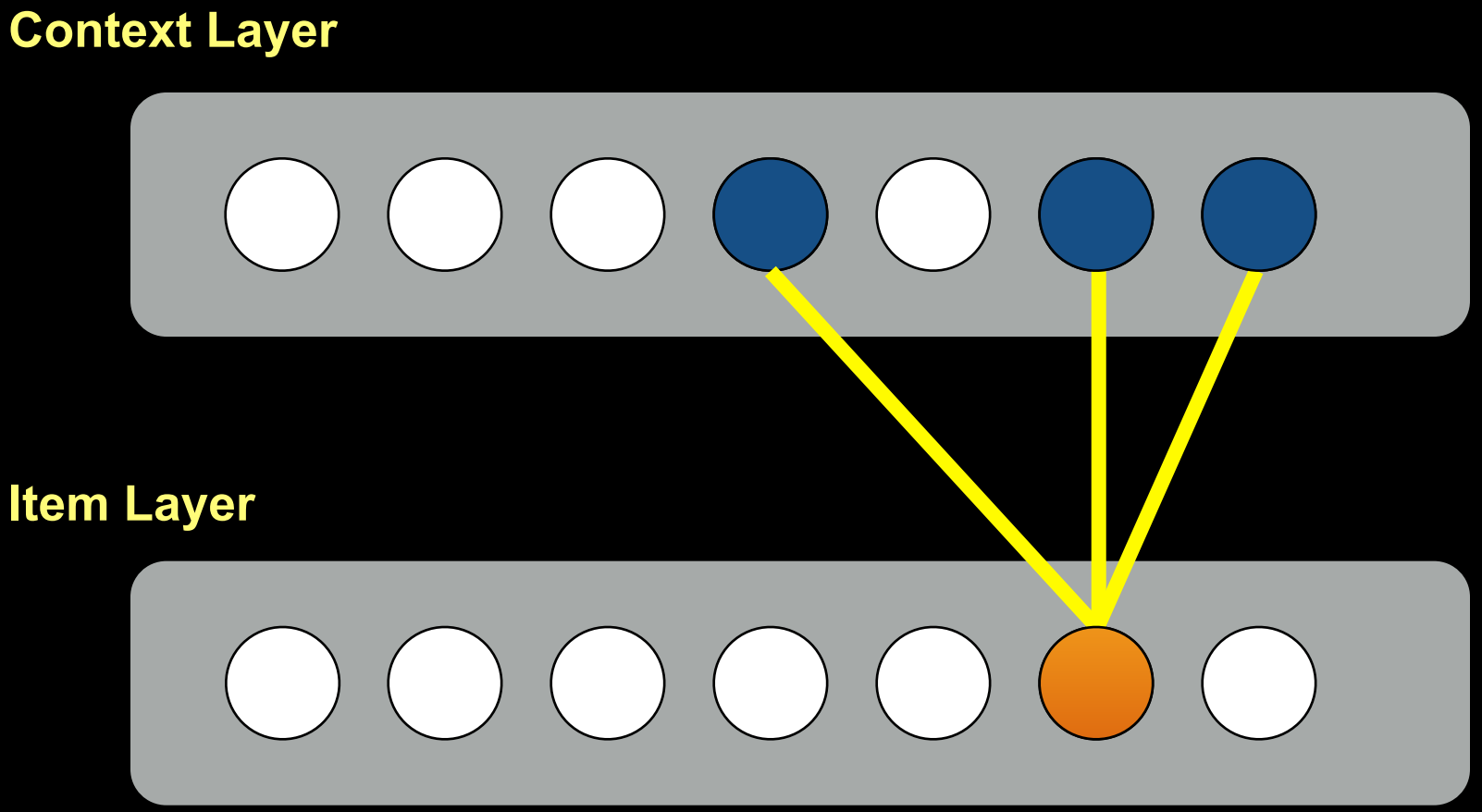

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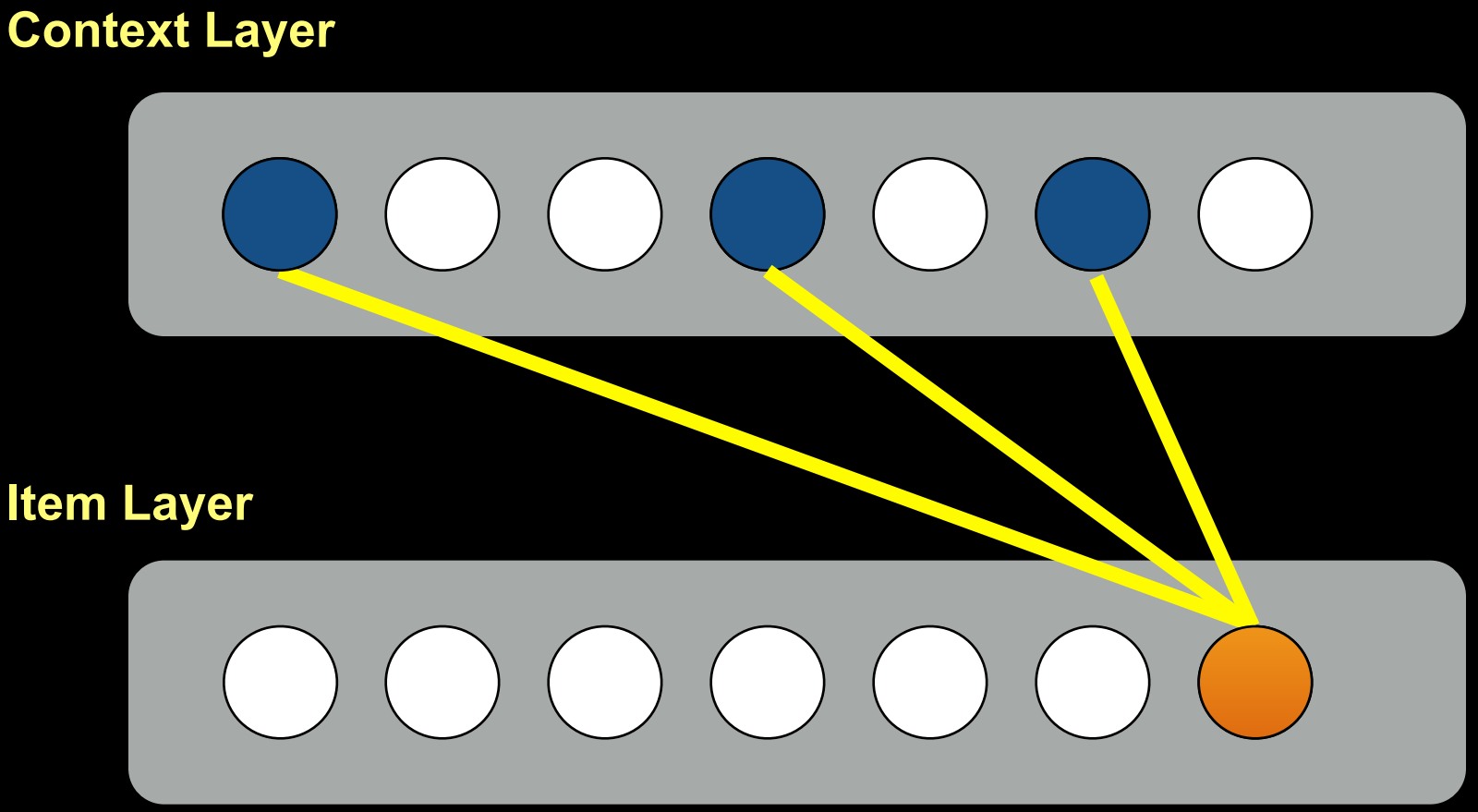
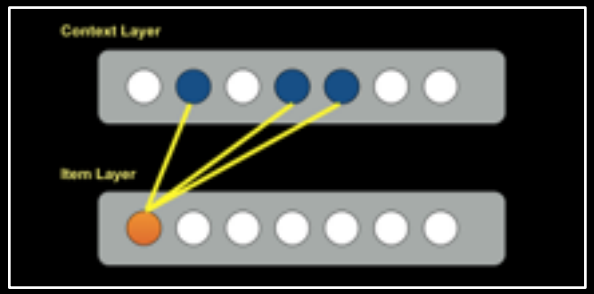


Stimulus Sampling Theory & Spacing

Massed Practice



Spaced Practice

Stimulus Sampling Theory & Spacing

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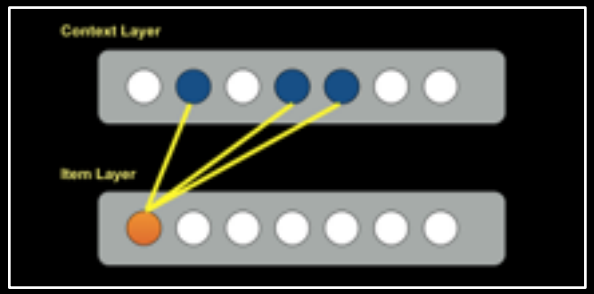

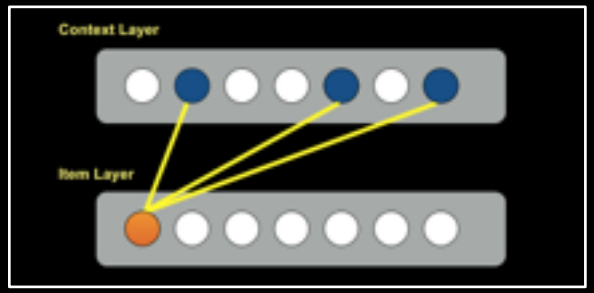

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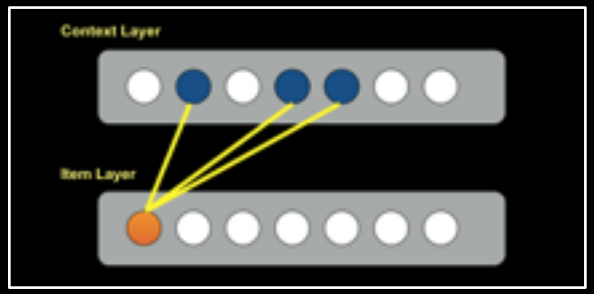

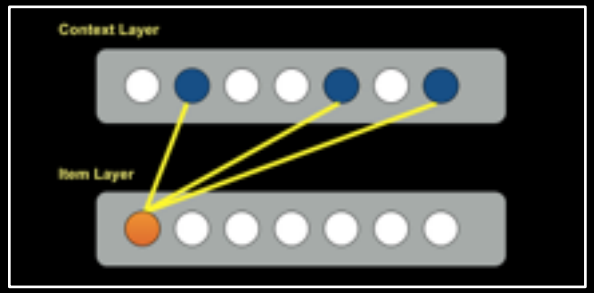

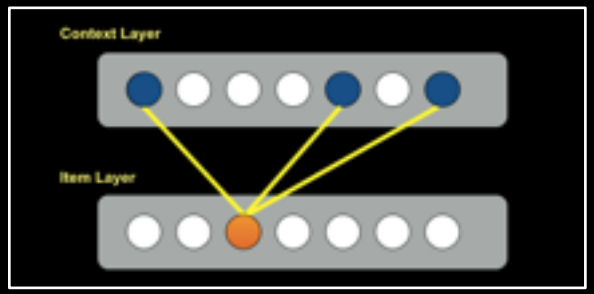

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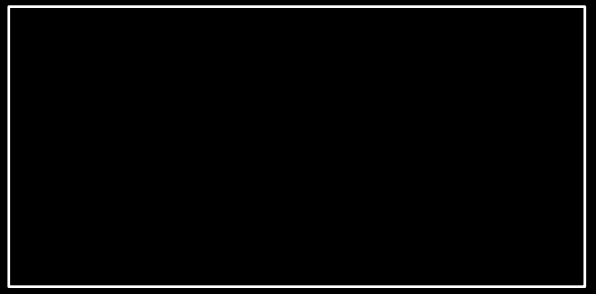

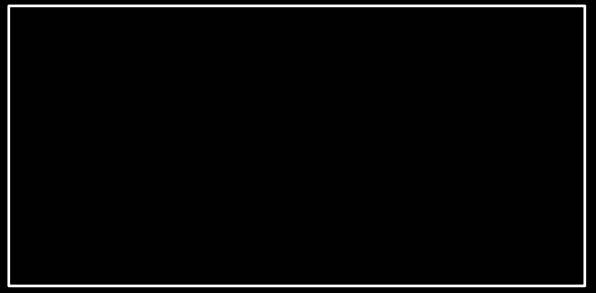

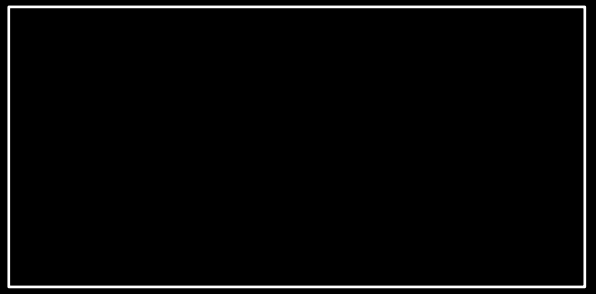

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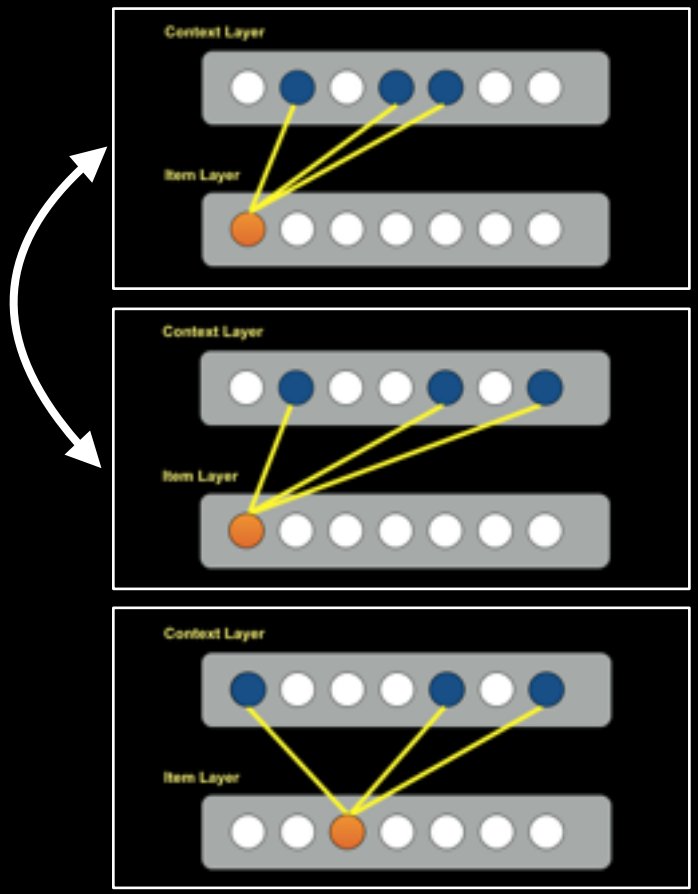

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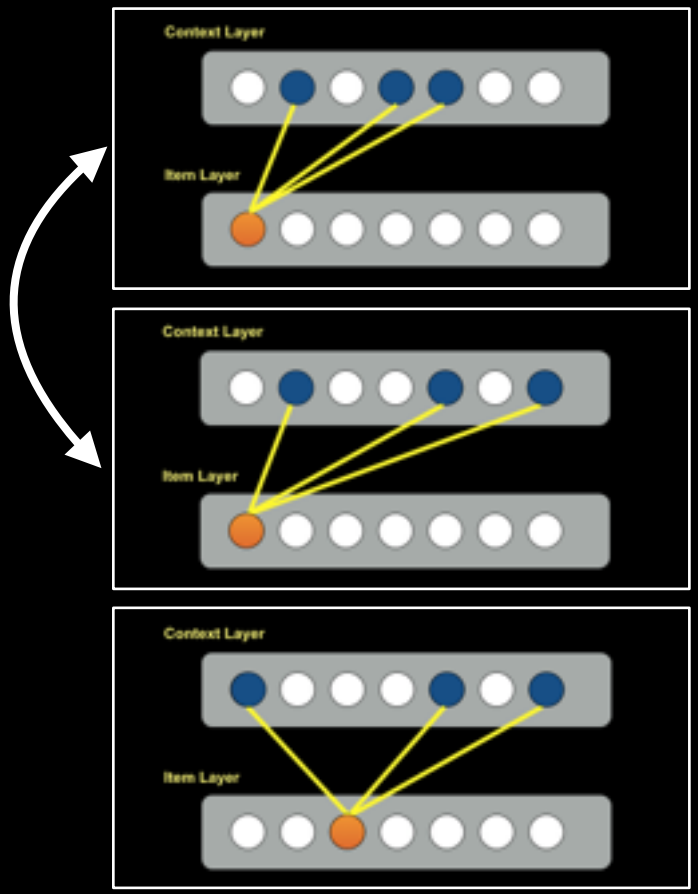

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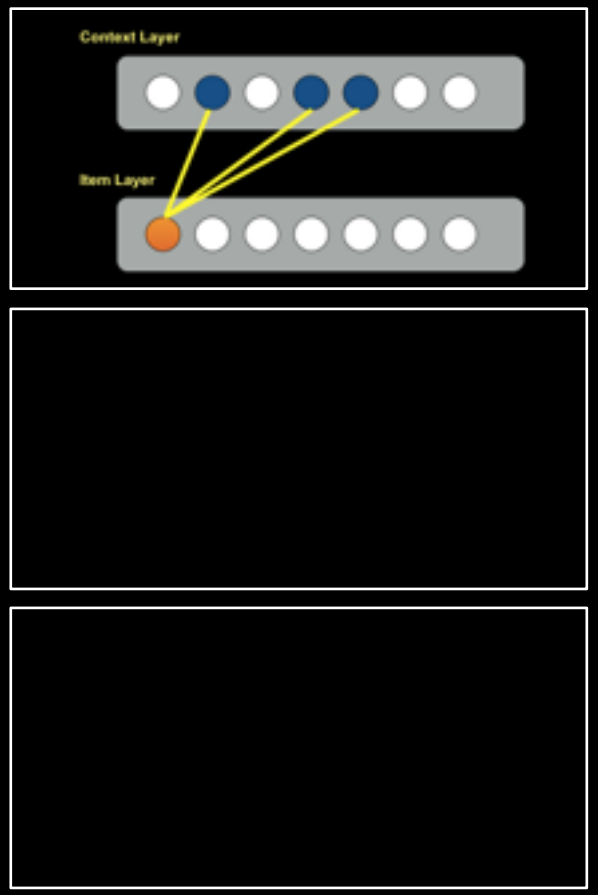

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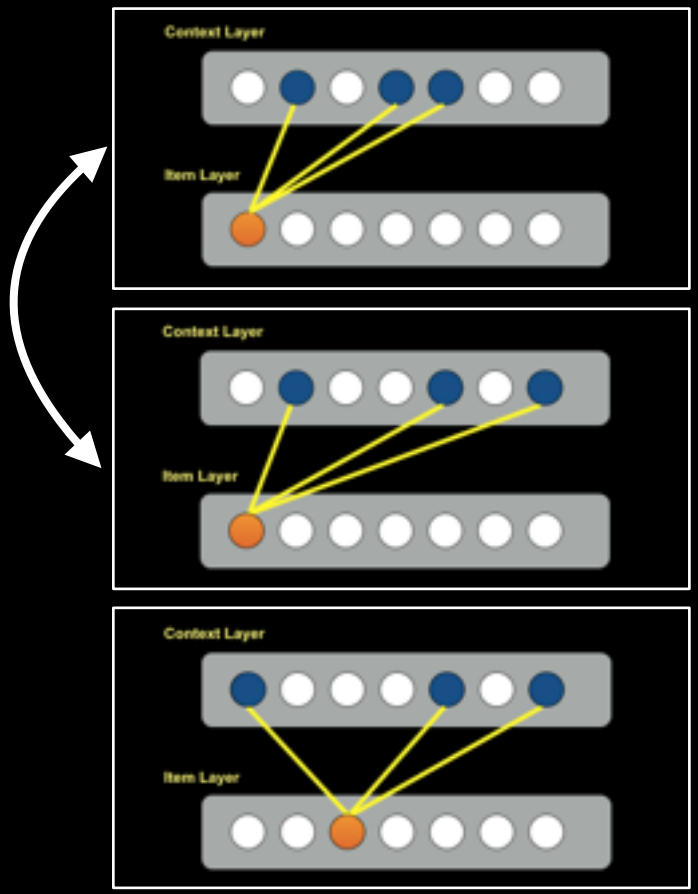
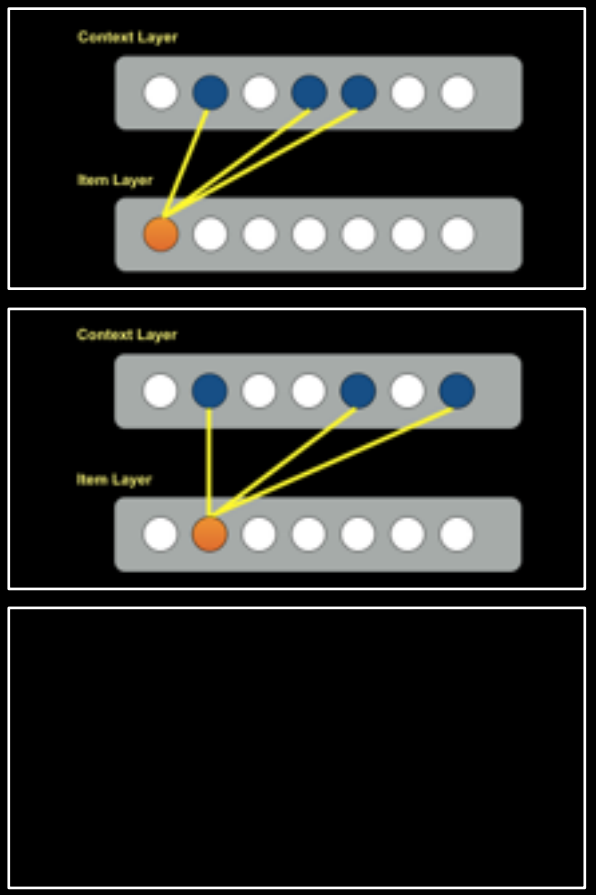
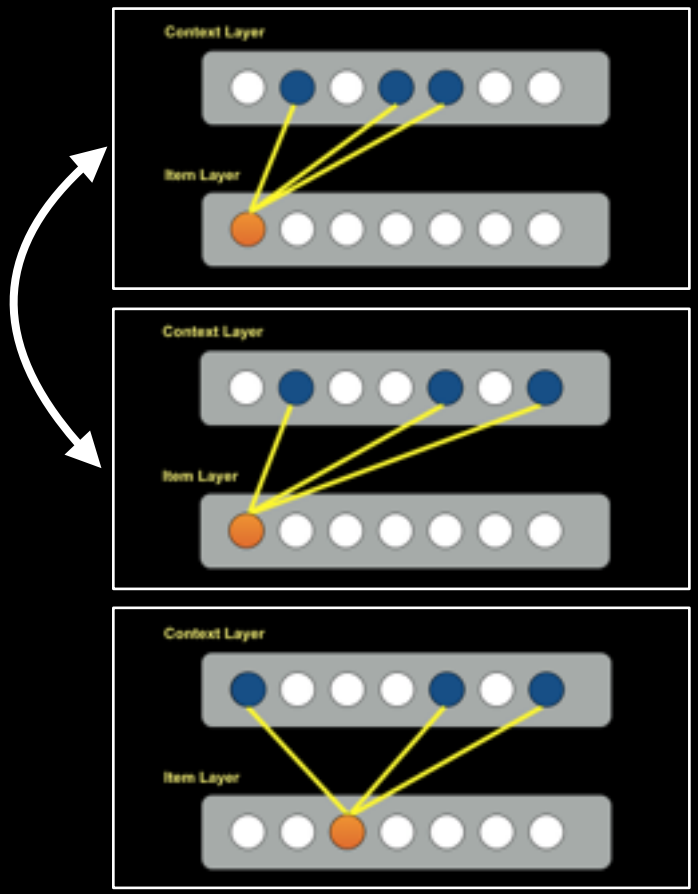


Spaced Practice

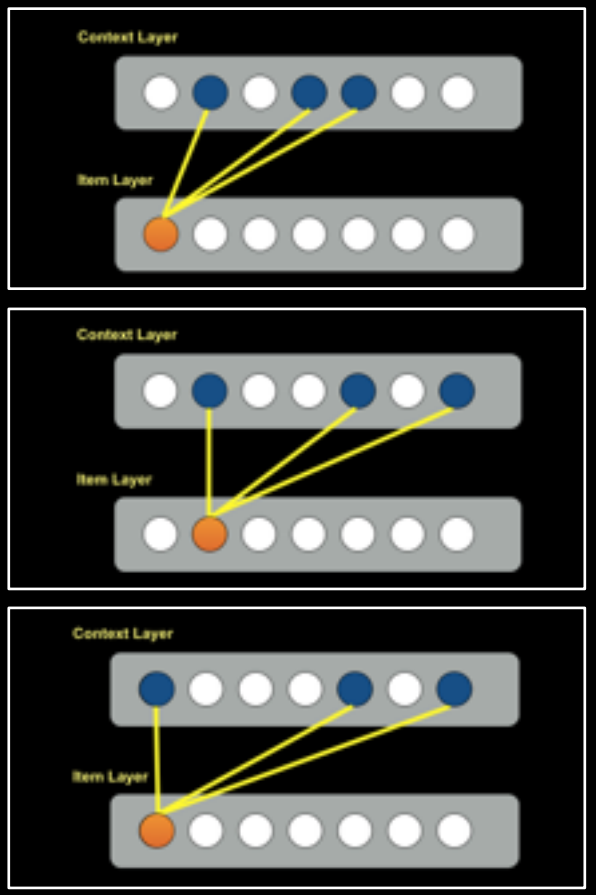


Stimulus Sampling Theory & Spacing

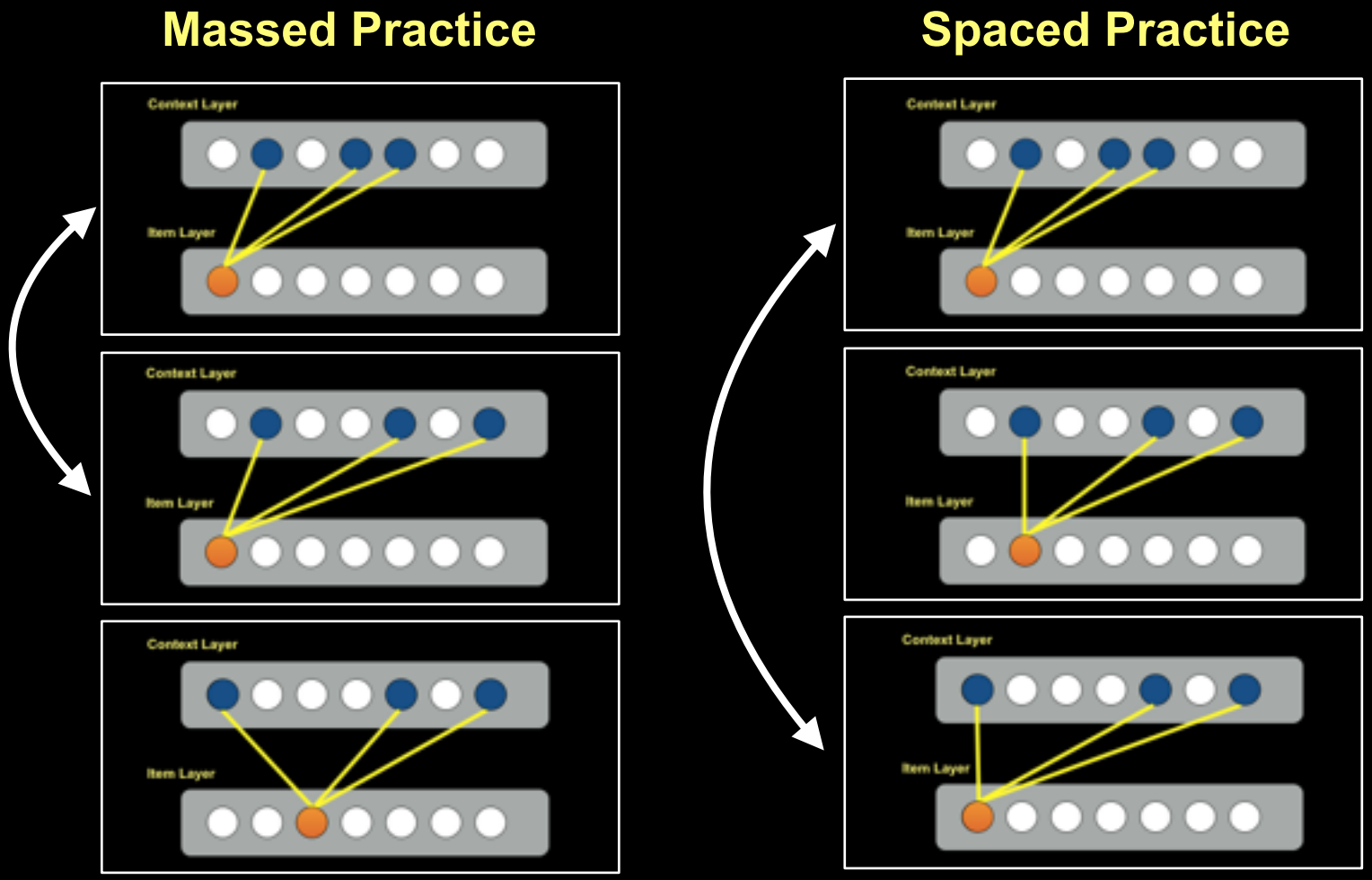
Massed Practice



Spaced Practice



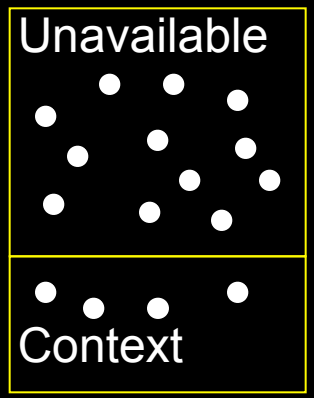
Stimulus Sampling Theory & Spacing



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

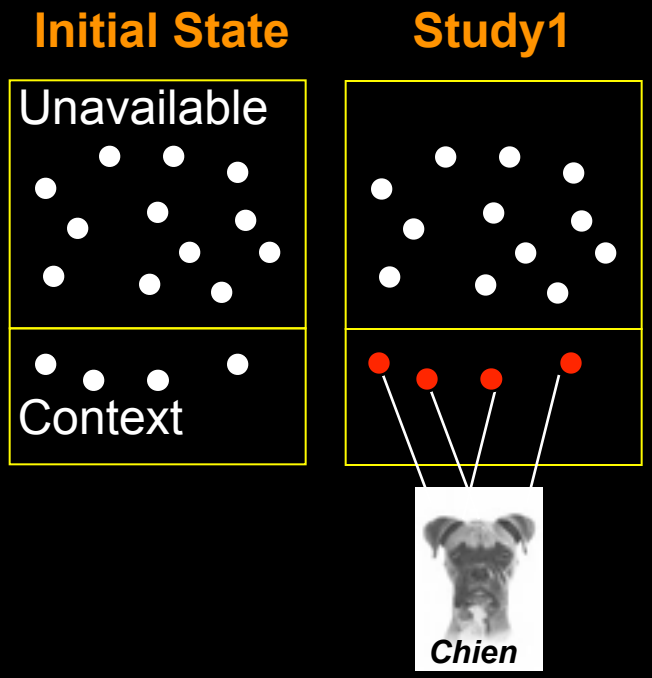
Stimulus Sampling Theory & Spacing

Initial State



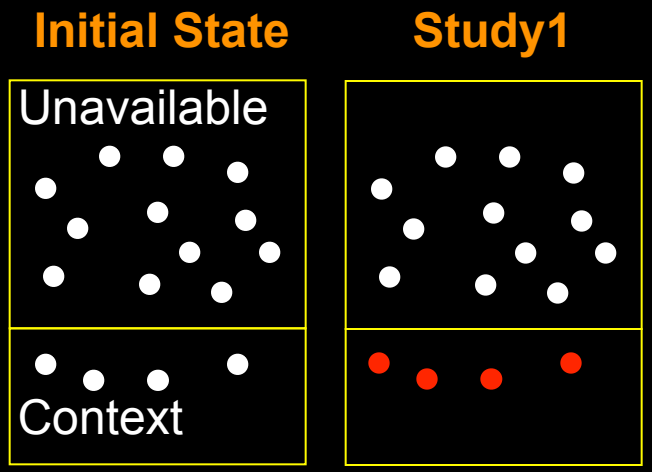
(Estes, 1955)

Stimulus Sampling Theory & Spacing



(Estes, 1955)

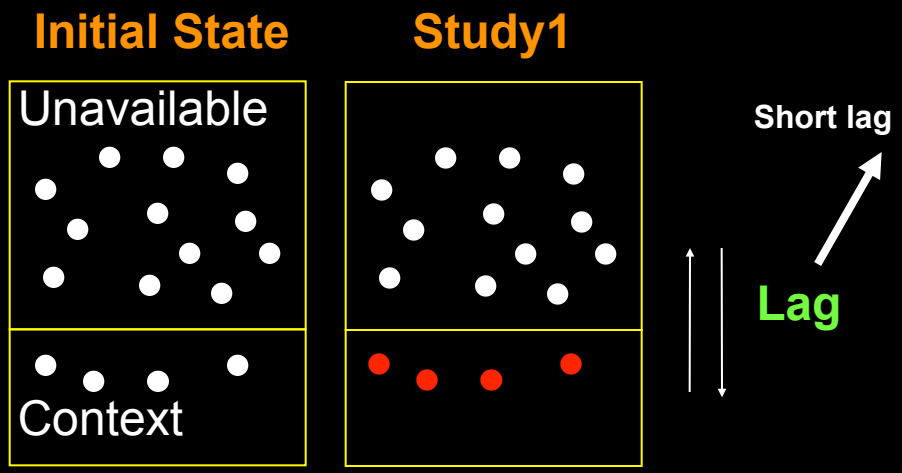
Stimulus Sampling Theory & Spacing



P(recall)=1

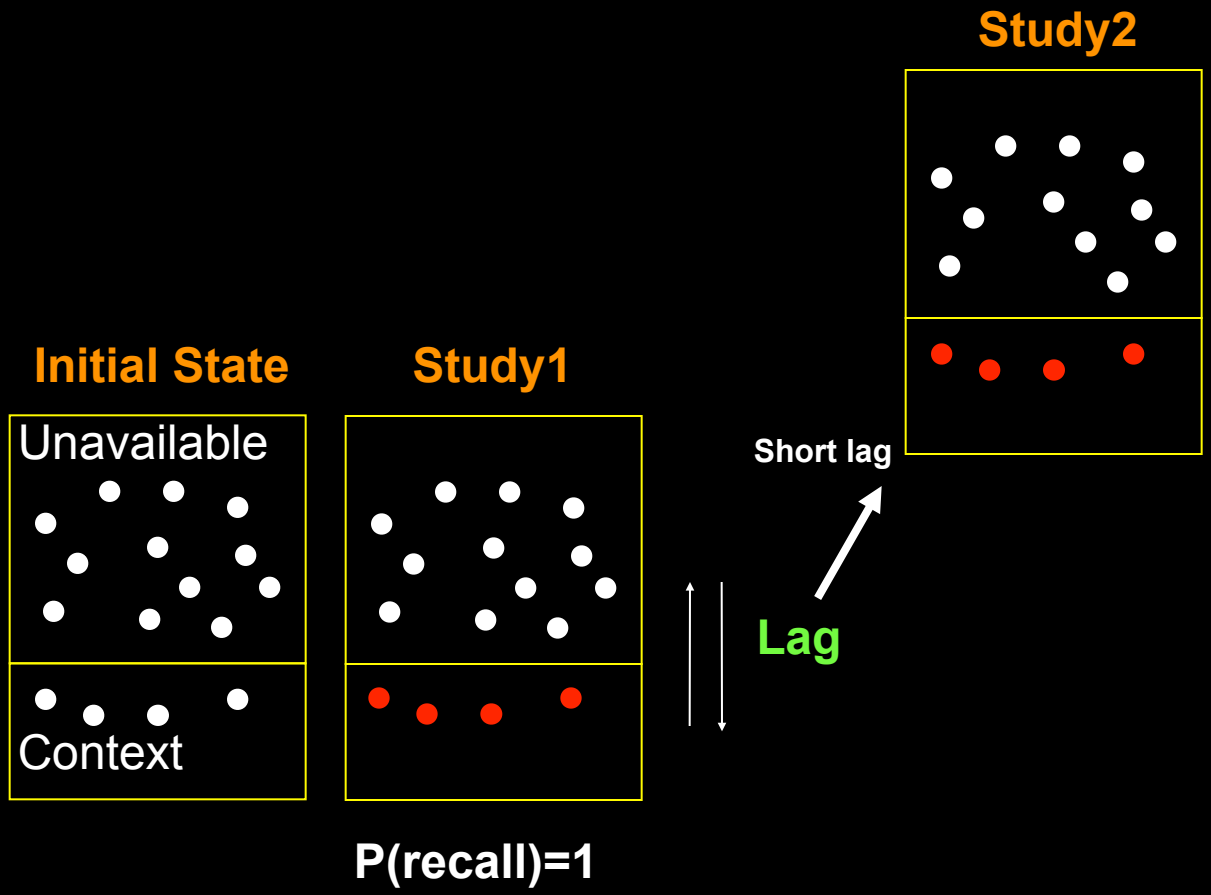
(Estes, 1955)

Stimulus Sampling Theory & Spacing



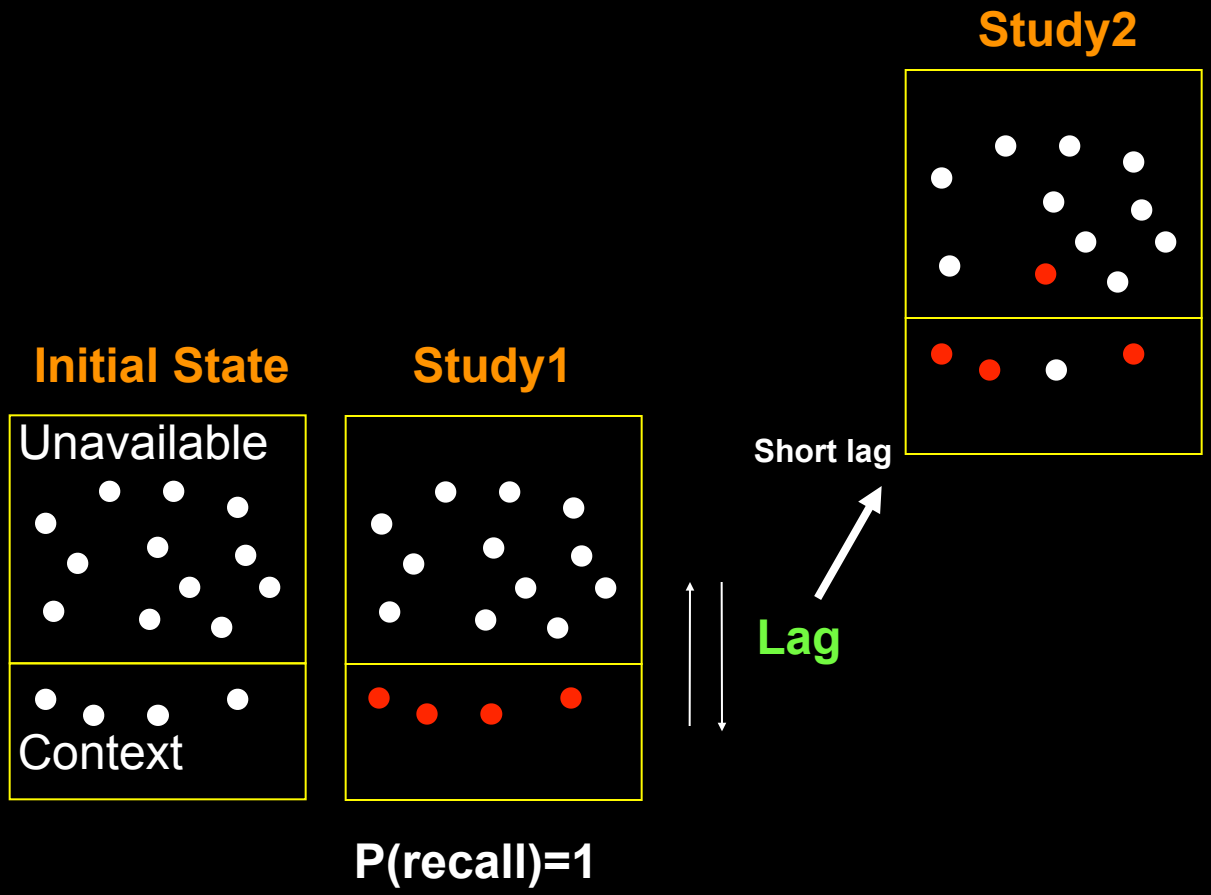
(Estes, 1955)

Stimulus Sampling Theory & Spacing



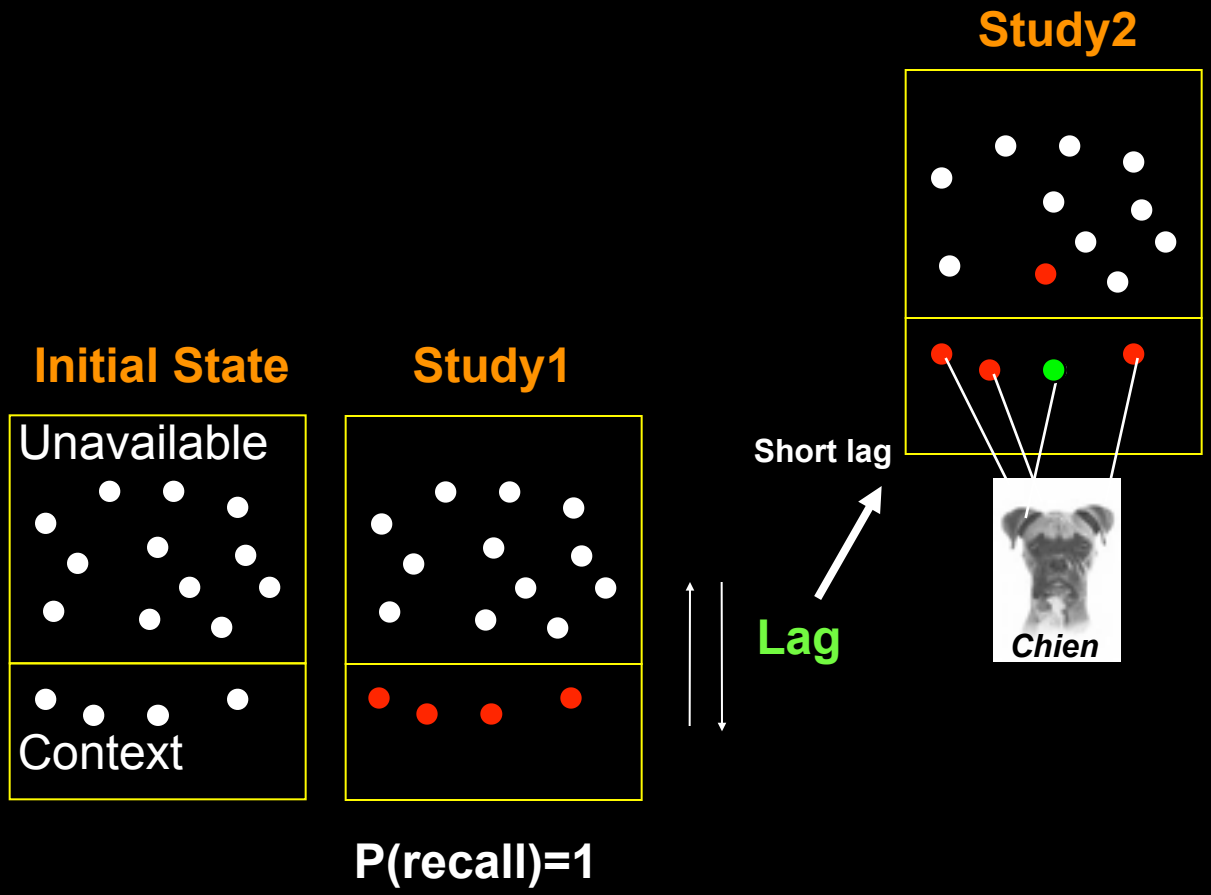
(Estes, 1955)

Stimulus Sampling Theory & Spacing



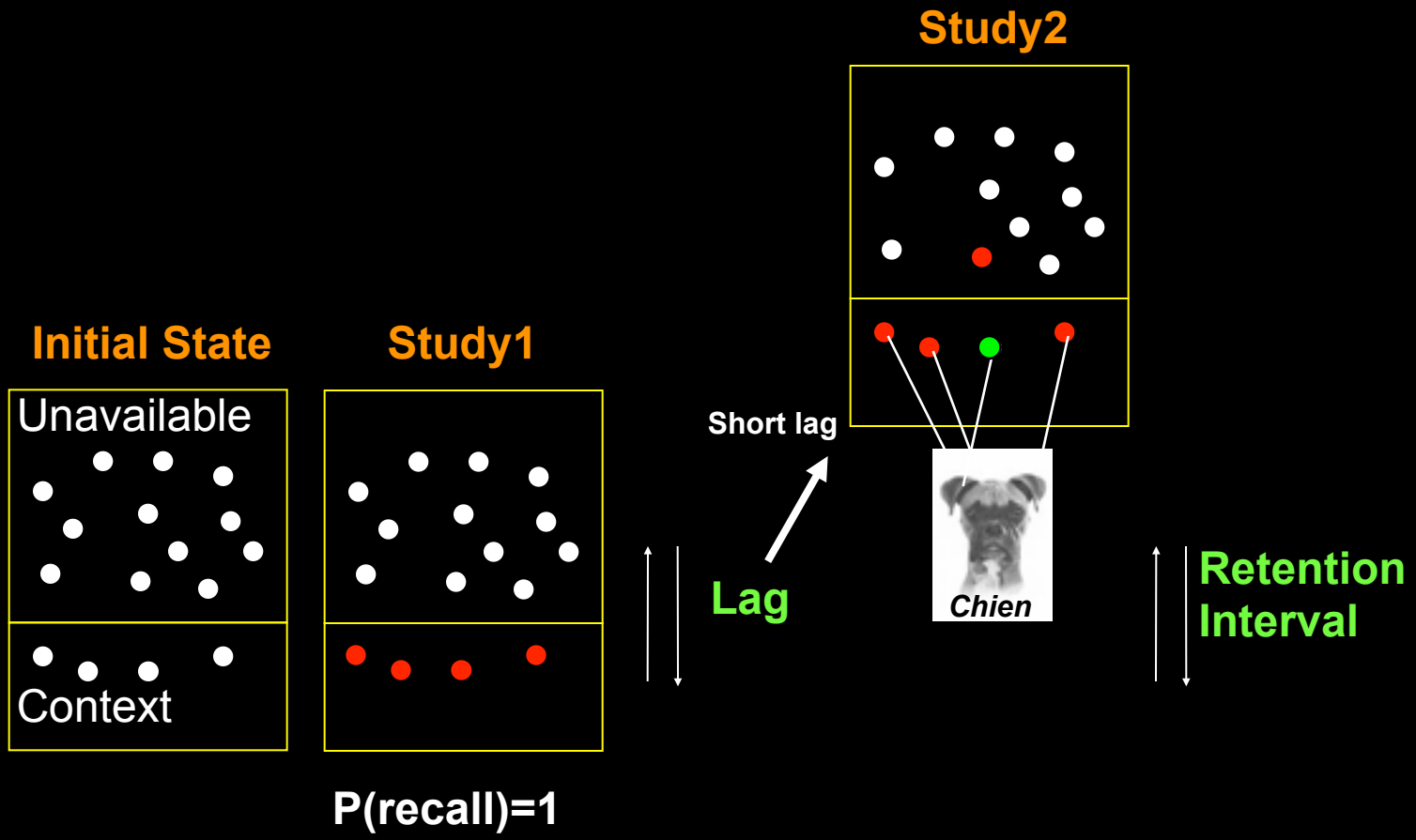
(Estes, 1955)

Stimulus Sampling Theory & Spacing



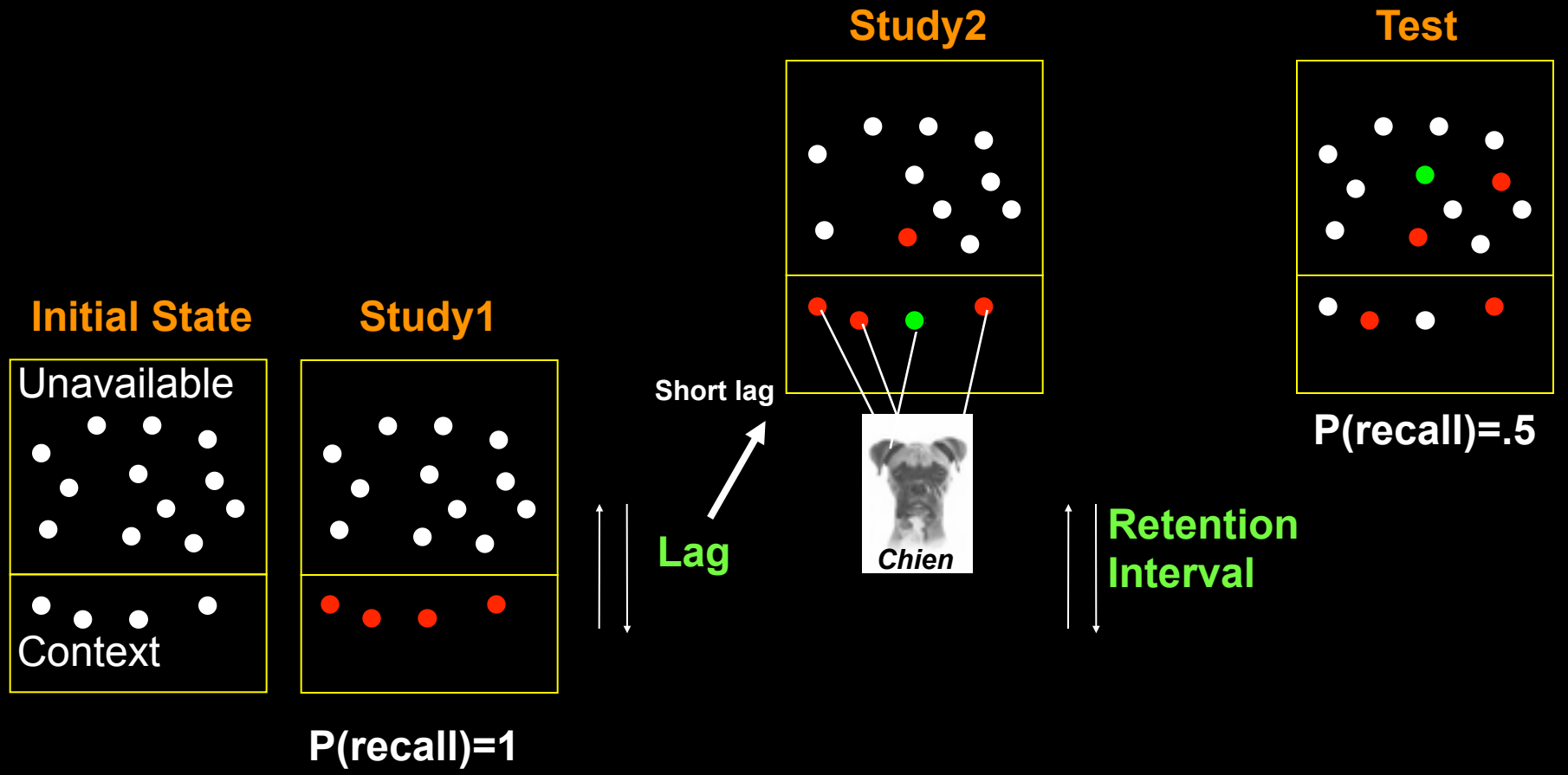
(Estes, 1955)

Stimulus Sampling Theory & Spacing



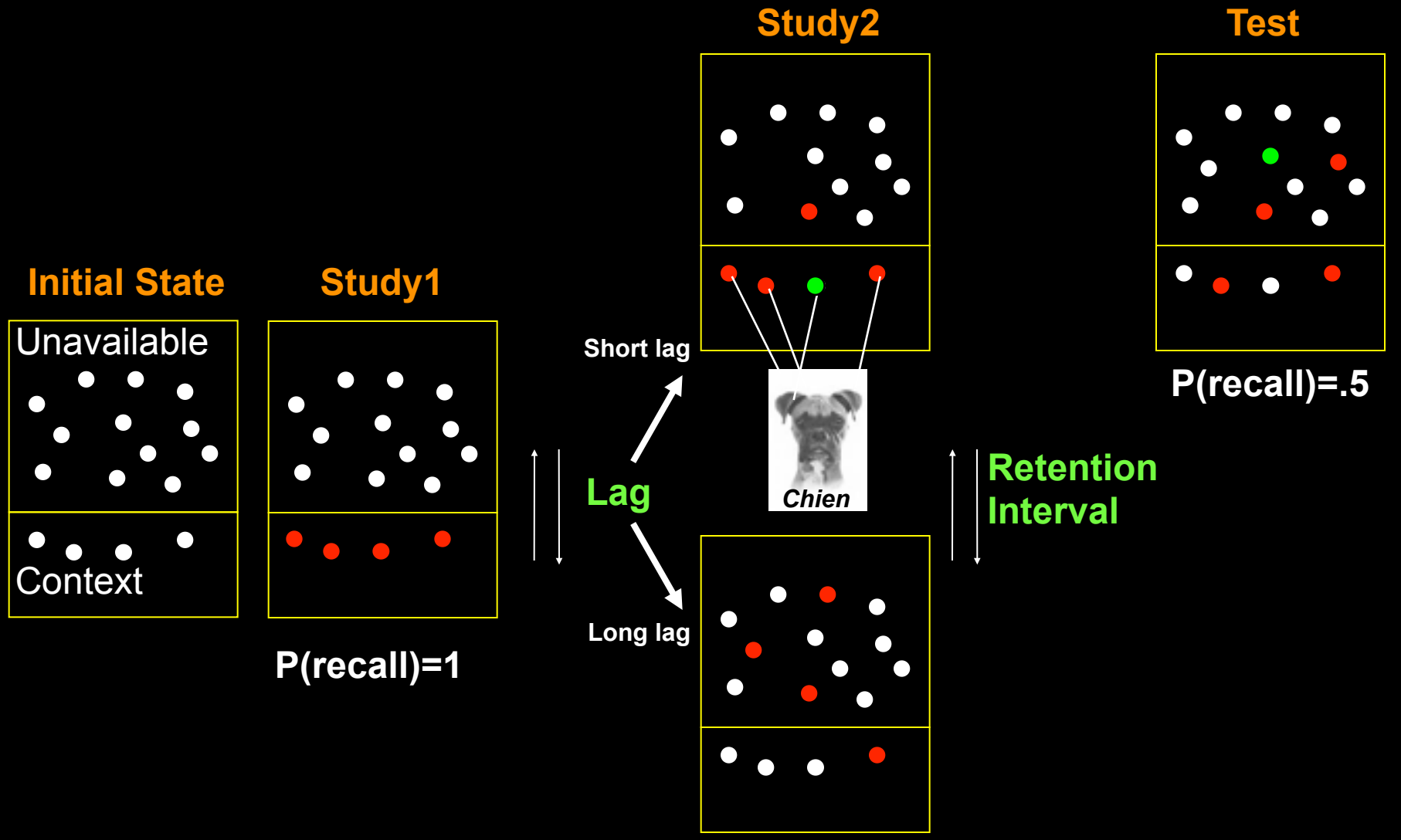
(Estes, 1955)

Stimulus Sampling Theory & Spacing



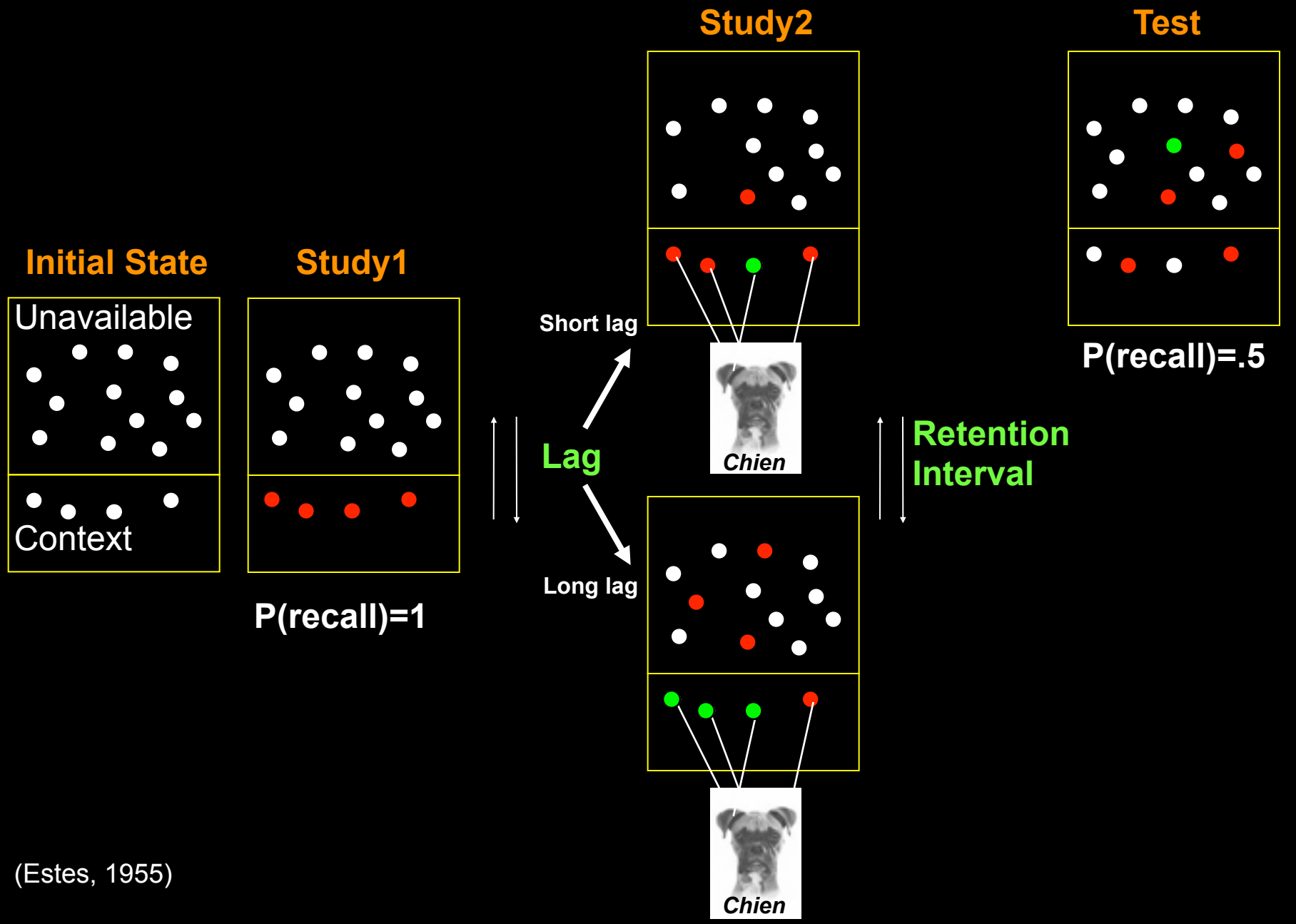
(Estes, 1955)

Stimulus Sampling Theory & Spacing



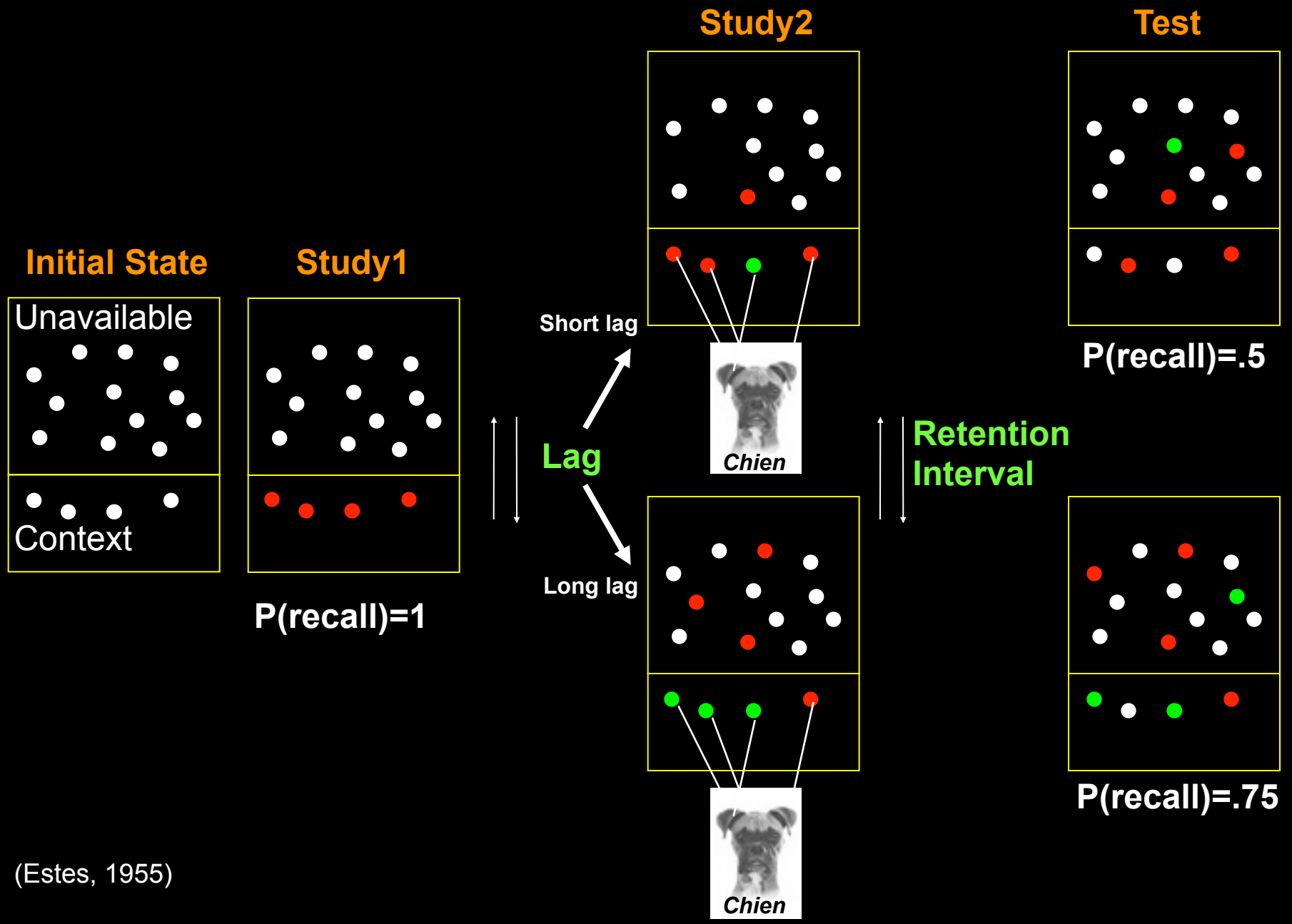
(Estes, 1955)

Stimulus Sampling Theory & Spacing



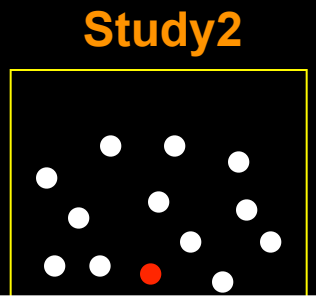
(Estes, 1955)

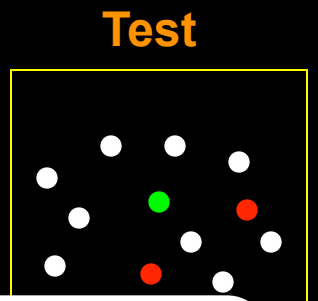
Stimulus Sampling Theory & Spacing



(Estes, 1955)

Stimulus Sampling Theory & Spacing





- 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

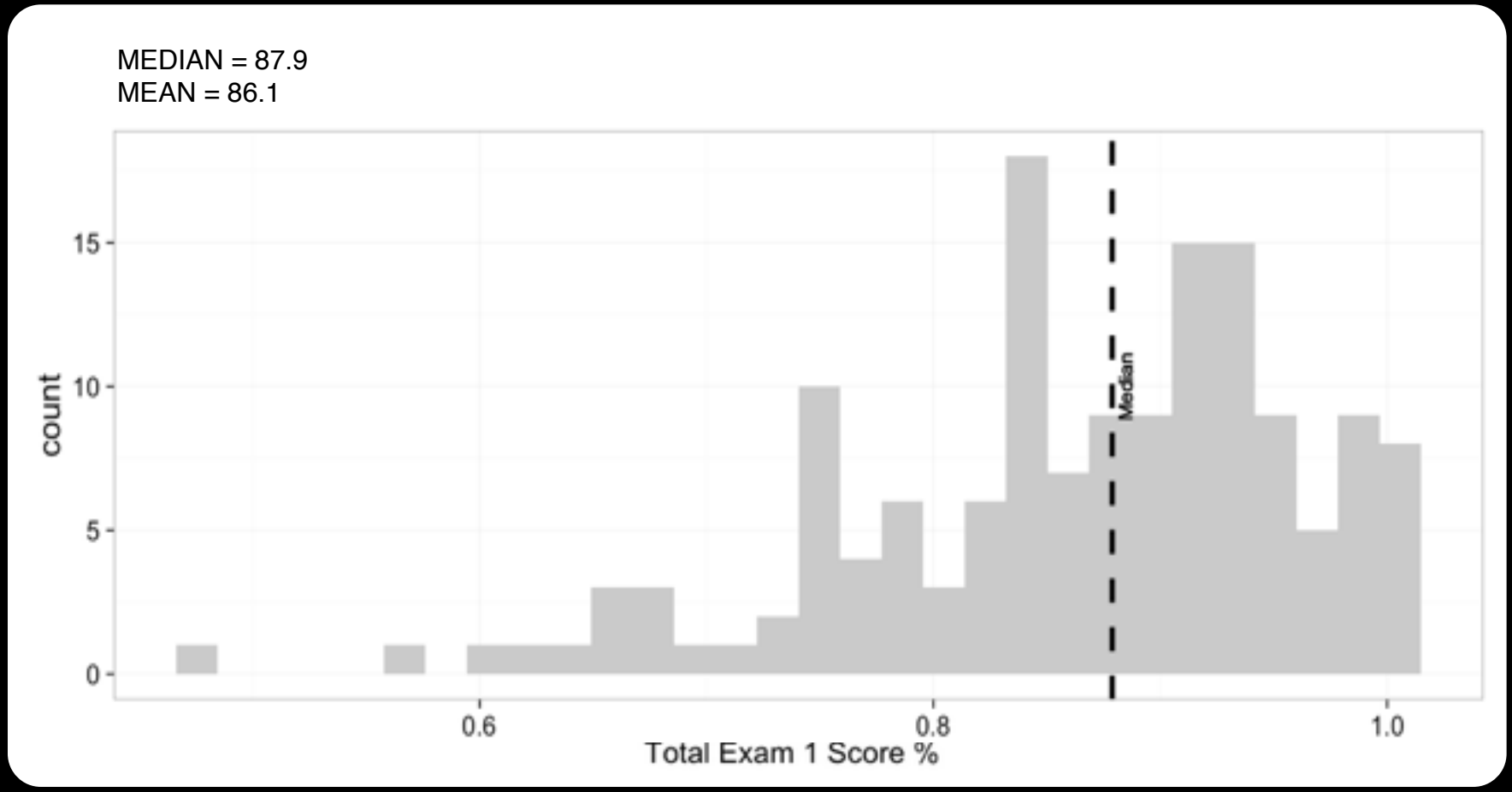
P(recall)=.75

(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

Midterm 1 Summary



Guidance: A-/B+ ~ 90%; B-/C+ ~ 78%; <65% see us