

CSCI 1377

Tools for Thought

Mnemonics I

Science and Tradition of Memory

“Now let us turn to the treasure-house of inventions, the custodian of all the parts of rhetoric, memory.”

— *Ad Herennium*, circa 85 BCE

Logistics before we begin

- **Weekly structure:** theory → practice → lab → assignment
 - Theory lectures cover primarily history & psychology of [memory, perception, ...]
 - Practice lectures cover systems, techniques, research, etc.
 - Labs (*new!*) help you use the tech on assignments that we don't cover in class
 - Assignments are usually a mixture of analysis/reflection & design/implementation
 - Anki deck will help you review the factual content of lectures
- **Midterm** will be 6pm on 11/5, covering mostly theory
 - You DO NOT need to memorize names or dates of historical events / figures
 - You DO need to know the what and the why of core concepts
 - “Which of the following best describes preattentive processing in the human visual system?”
 - “Explain why measures of sound and image quality are modified with decibels for practical use by humans.”
 - “Using the description of skilled reading given in class, construct an argument for why phonics would be a more effective means of developing skilled reading than three cueing.”

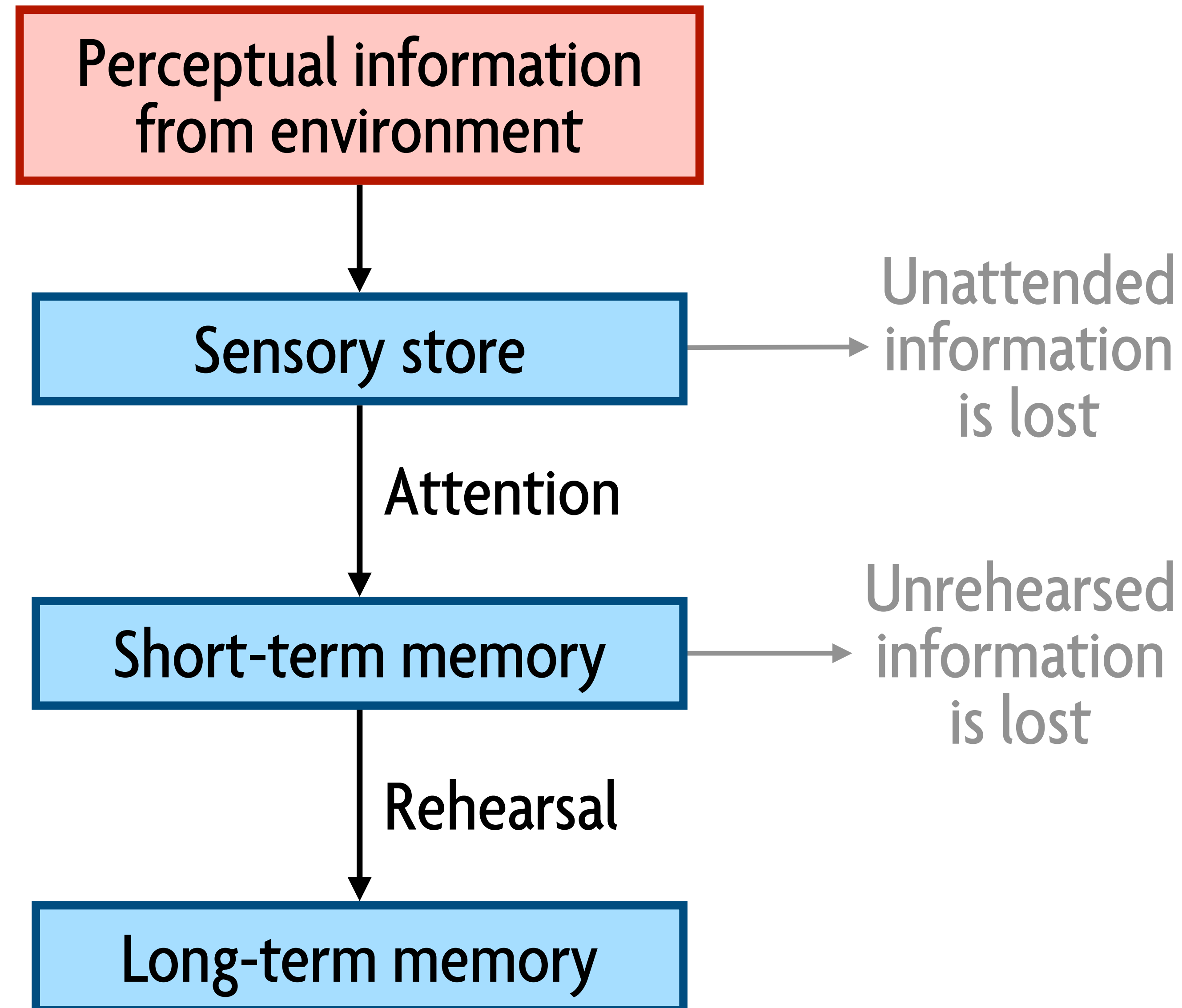
Logistics before we begin

- **Before class:** no readings required, except where noted
 - All readings are available on the website for your enjoyment
- **In class:** come ready to listen, take notes, discuss
 - NO LAPTOPS, you cannot distract your classmates with a bright screen
 - Tablets generally ok, but keep the brightness down
 - Lectures lean content-heavy, but I will always balance w/ interaction
- **After class:** careful w/ noise in the hallways
 - Admins work just outside of 477, please don't disturb them

What does it mean to remember?

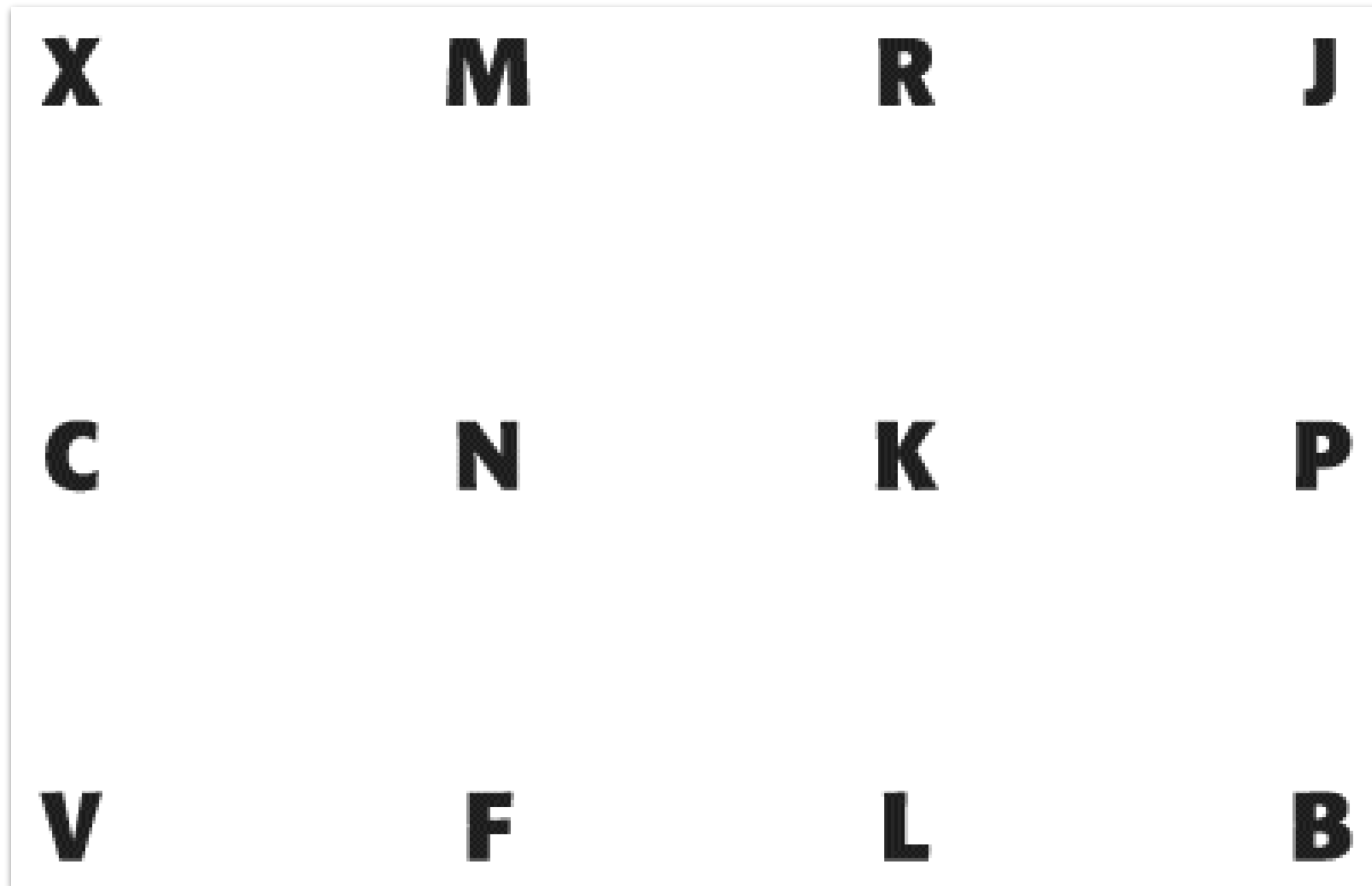
- **Tasks:** recognition vs. recall
 - *Recognition*: here's a photo of someone, do you recognize them?
 - *Recall*: here's a piece of paper, can you recall what someone looks like?
 - Other factors:
 - Time delay between learning and memory test
 - How much other information is being memorized
- **Information:** declarative vs. procedural knowledge
 - *Declarative knowledge*: the _____ is the powerhouse of the cell
 - *Procedural knowledge*: how to ride a bike, how to mentally do long addition

A basic model of memory

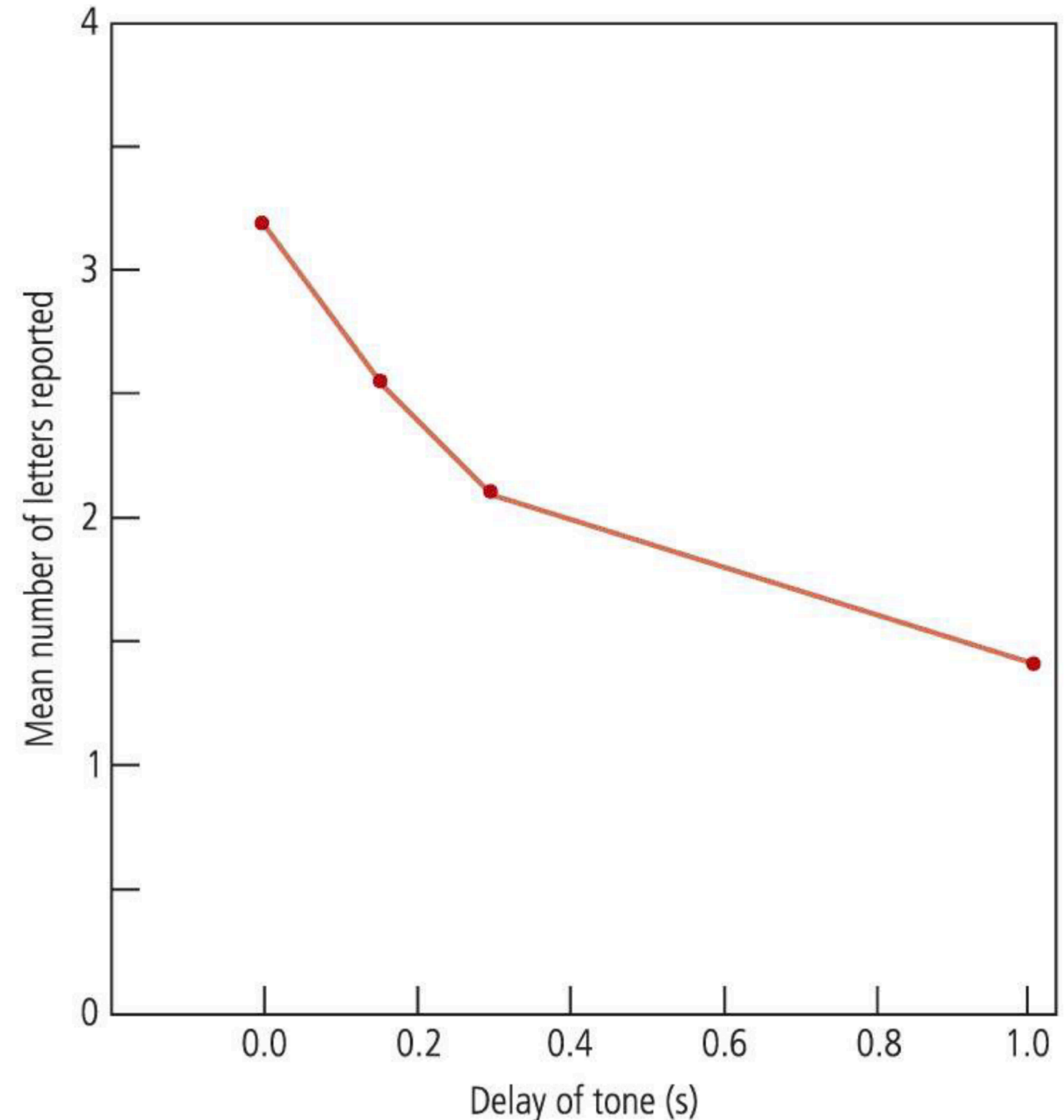


Sensory stores briefly hold perceptions

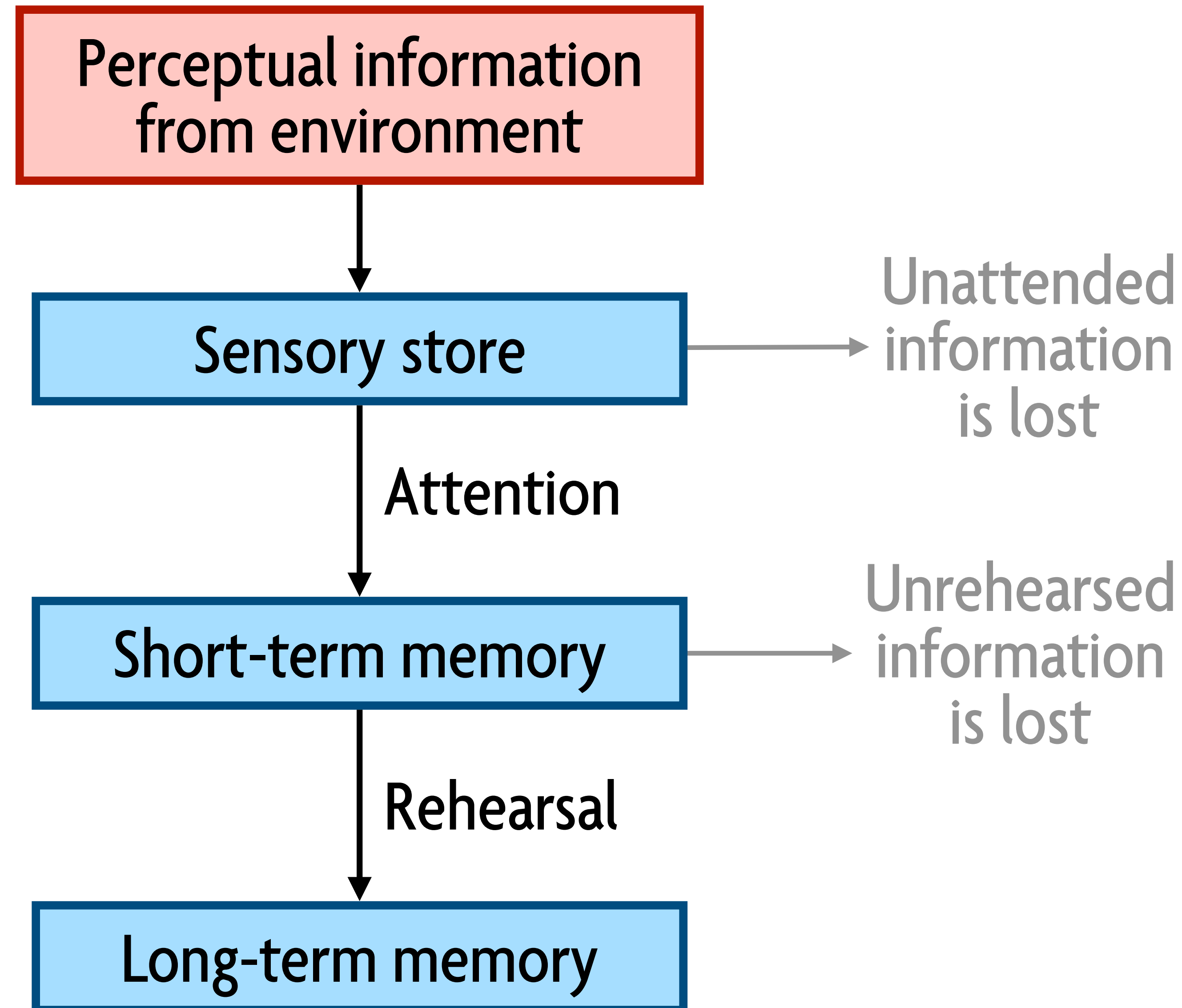
Materials: grids of letters



Procedure: show grid, remove, variable delay, cue attention to row, recall letters



A basic model of memory



Span of immediate recall is limited

3 8 4 1 1 9 7 2 5 2 4 9

Span of immediate recall is limited

3 8 4 1 1 9 7 2 5 2 4 9

Rehearsal must be combined with attention

2s

every 2, 6, or 18s, for 54s

3108 water, water, water, water, ... number?

7243 chair, chair, chair, chair, ... number?

... [repeat 54 times] ...

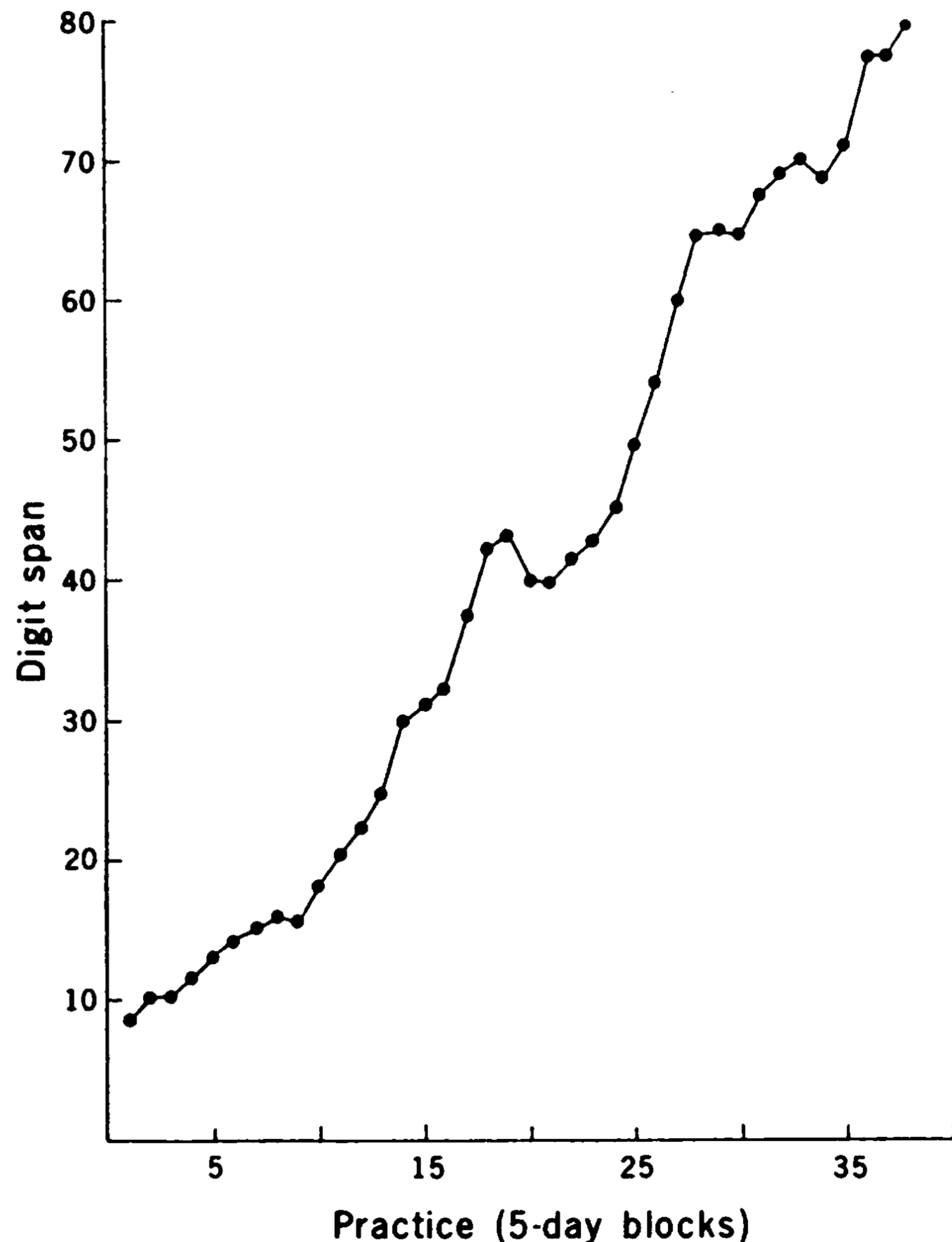
(Unexpectedly) Now recall the words you rehearsed.

~10% recall, regardless of rehearsal interval!

Span depends on the size of “chunks”

2 0 2 6 0 9 1 5 1 3 7 7

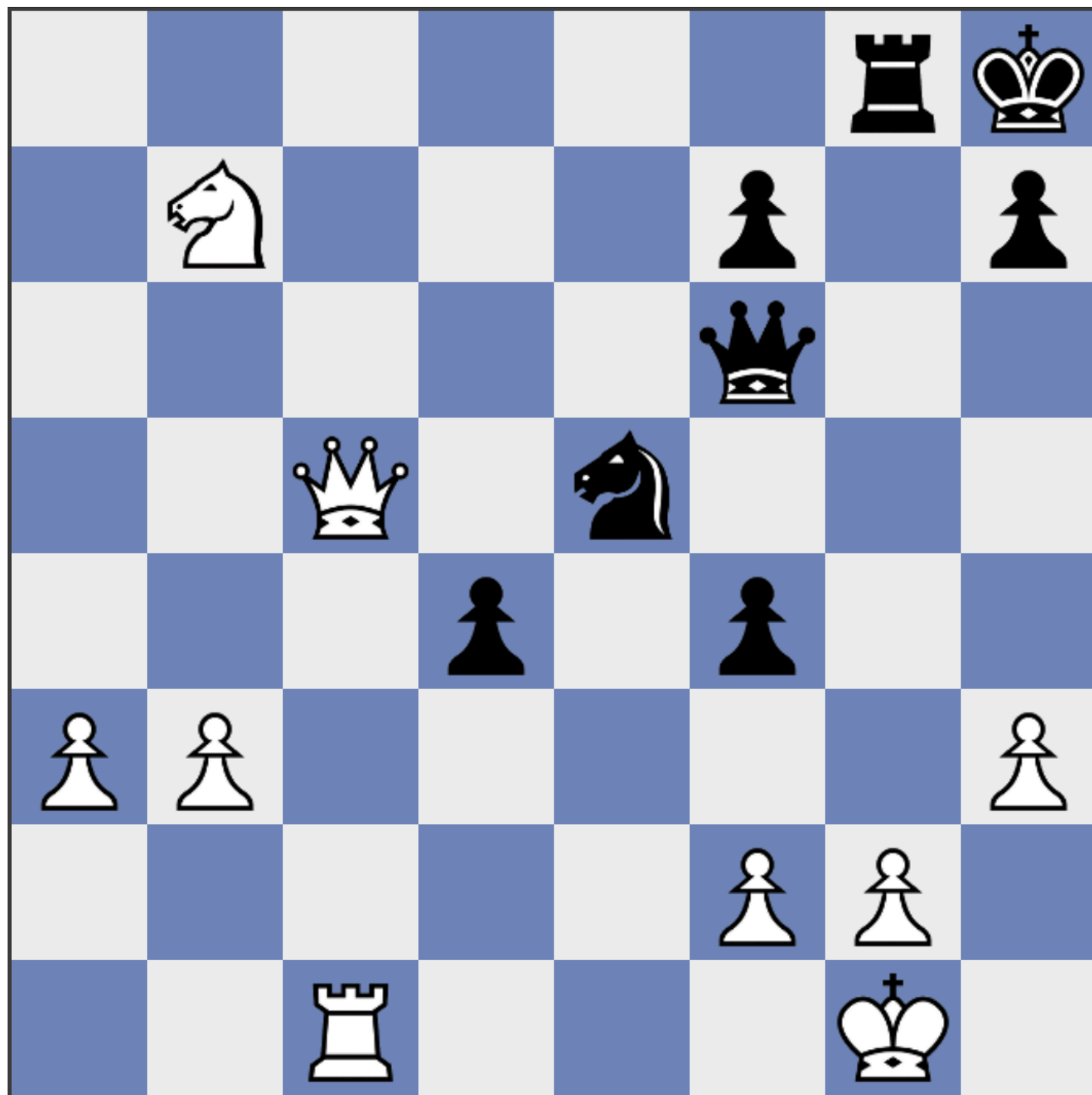
Chunking is learned and domain-specific



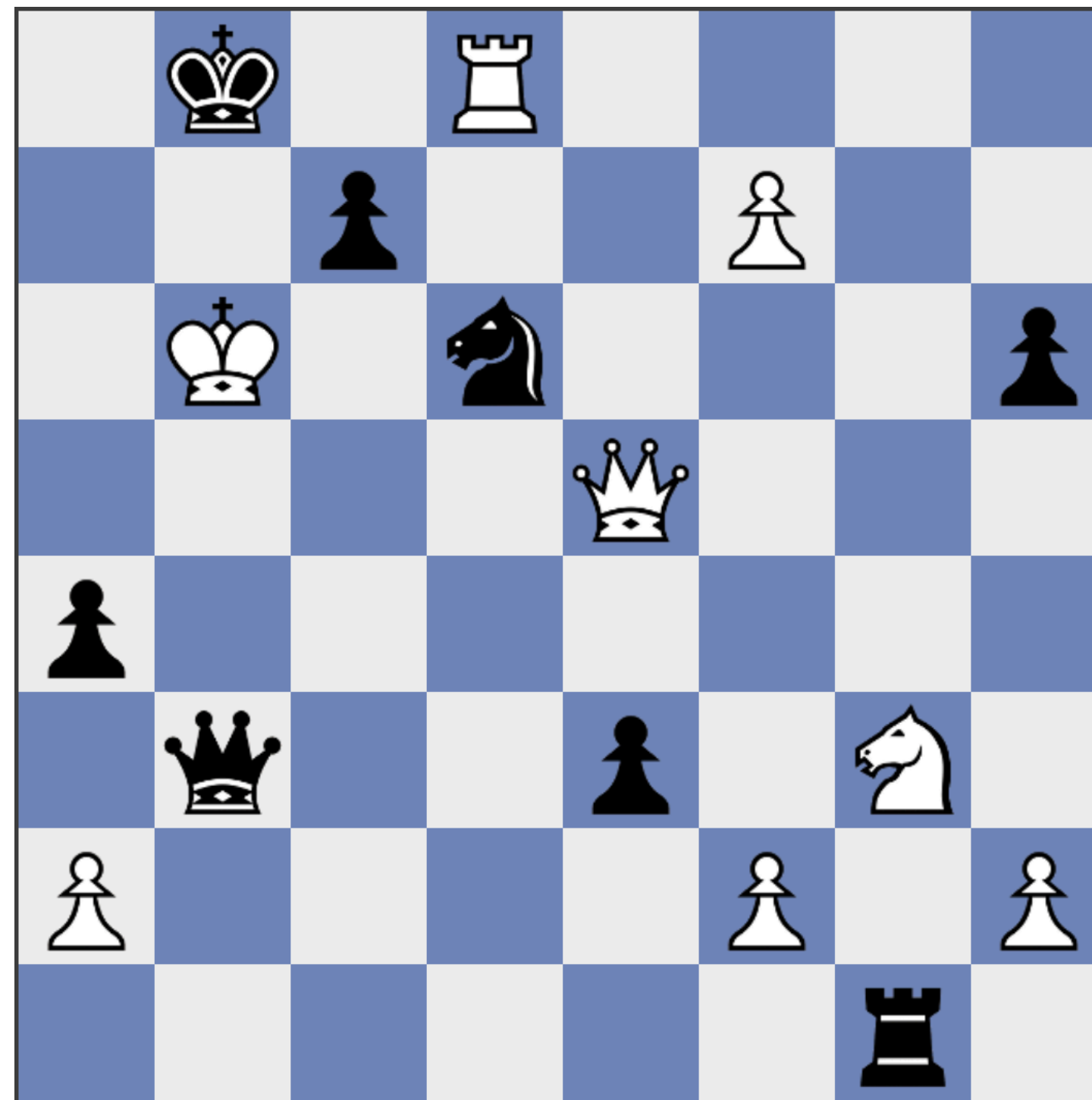
“What S.F. did was to categorize 3- and 4-digit groups as running times for various races. For example, 3492 was recoded as "3 minutes and 49 point 2 seconds, near world-record mile time". During the first 4 months, S.F. gradually constructed an elaborate set of mnemonic associations based initially on running times and then supplemented with ages (893 was "89 point 3, very old man") and dates (1944 was "near the end of World War II") for those sequences that could not be categorized as times.”

Chess masters chunk realistic positions

Materials: chess boards configurations



Deep Blue vs. Garry Kasparov, 1996
Game 2, after move 29. Nxb7 Ne5



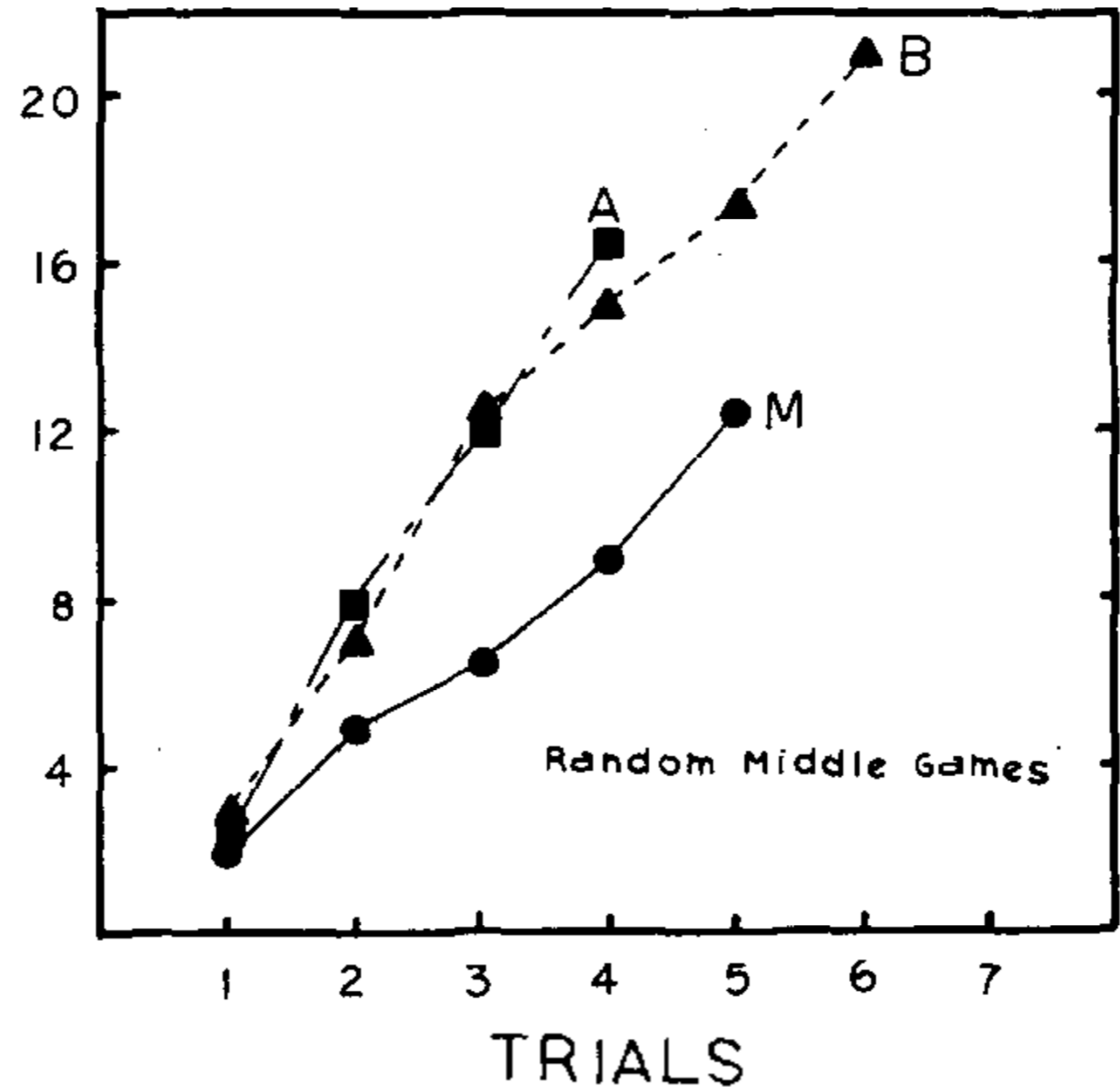
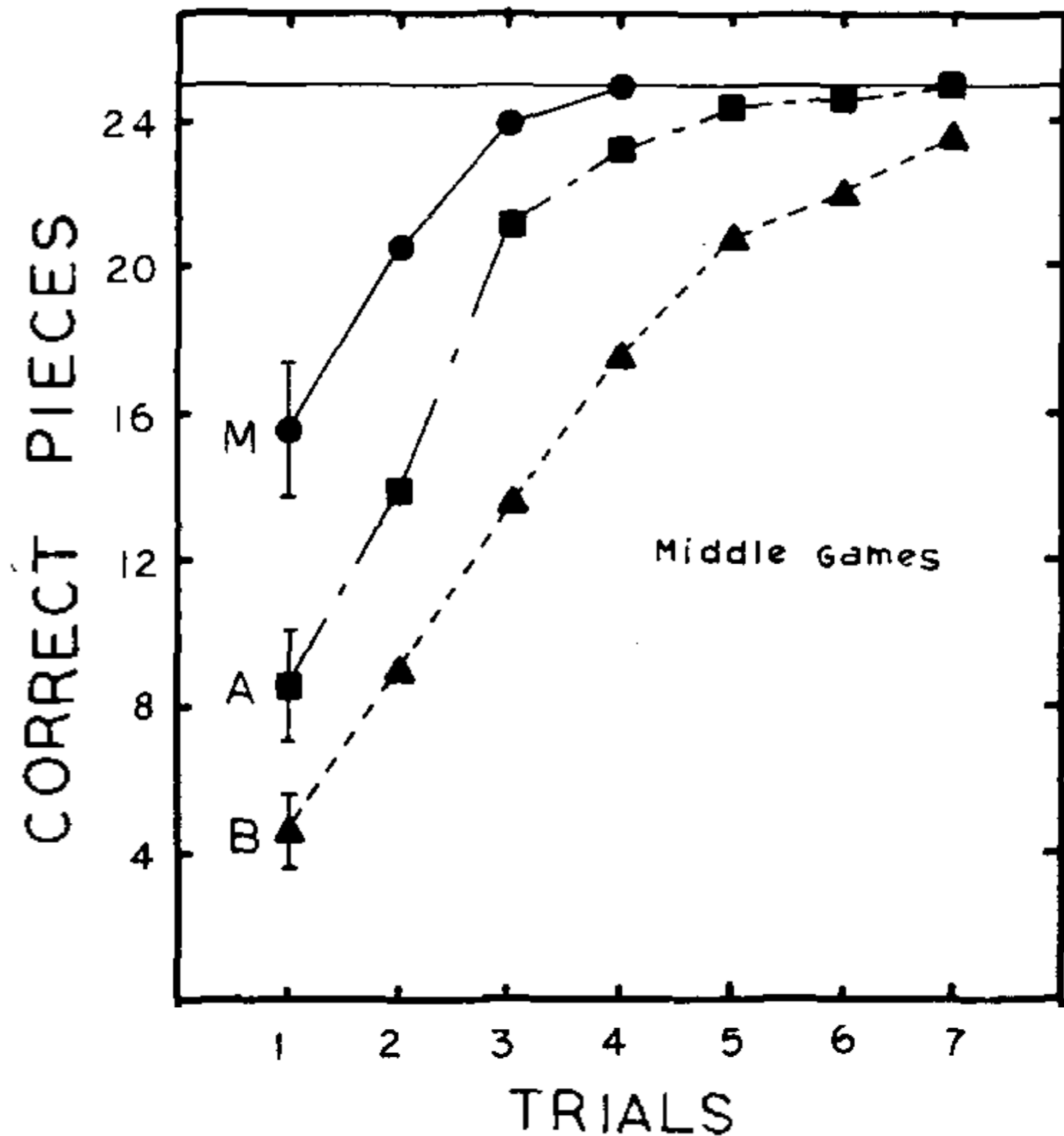
Same board, shuffled

Procedure:

- see board 5s
- remove board
- try to reconstruct
- repeat until correct

Chess masters chunk realistic positions

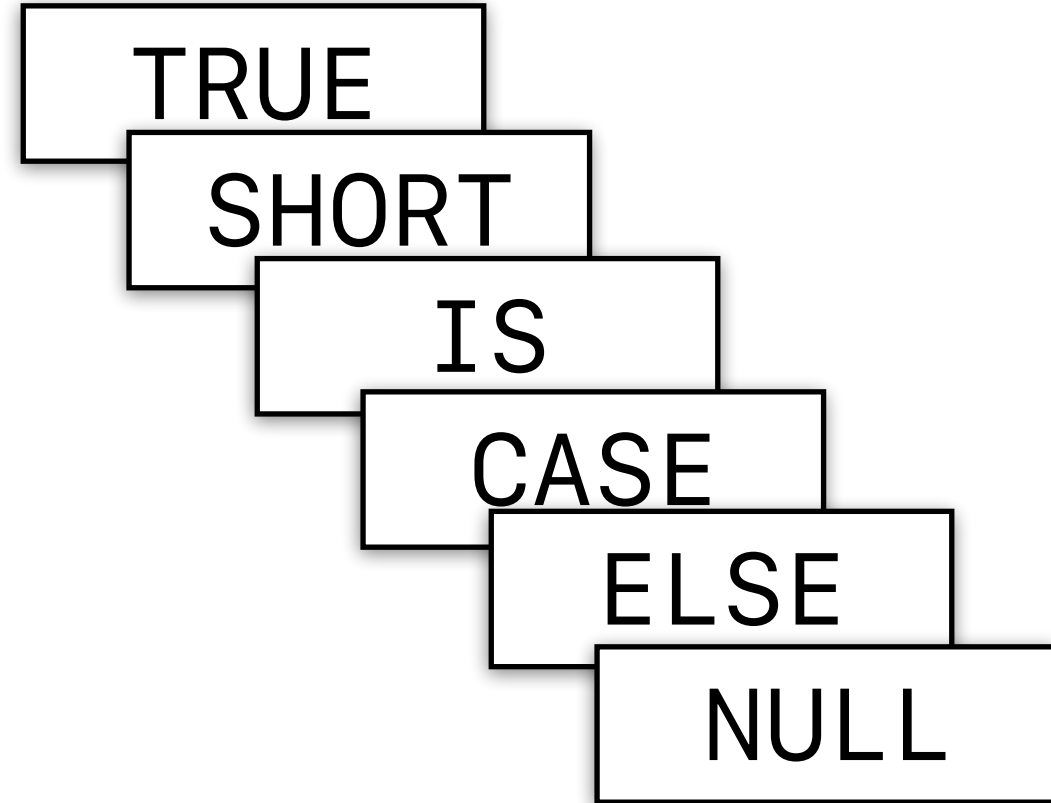
M = "master," A = "class A,"
B = "beginner"



Expert programmers chunk semantically related language keywords

Materials:

ALGOL W keywords

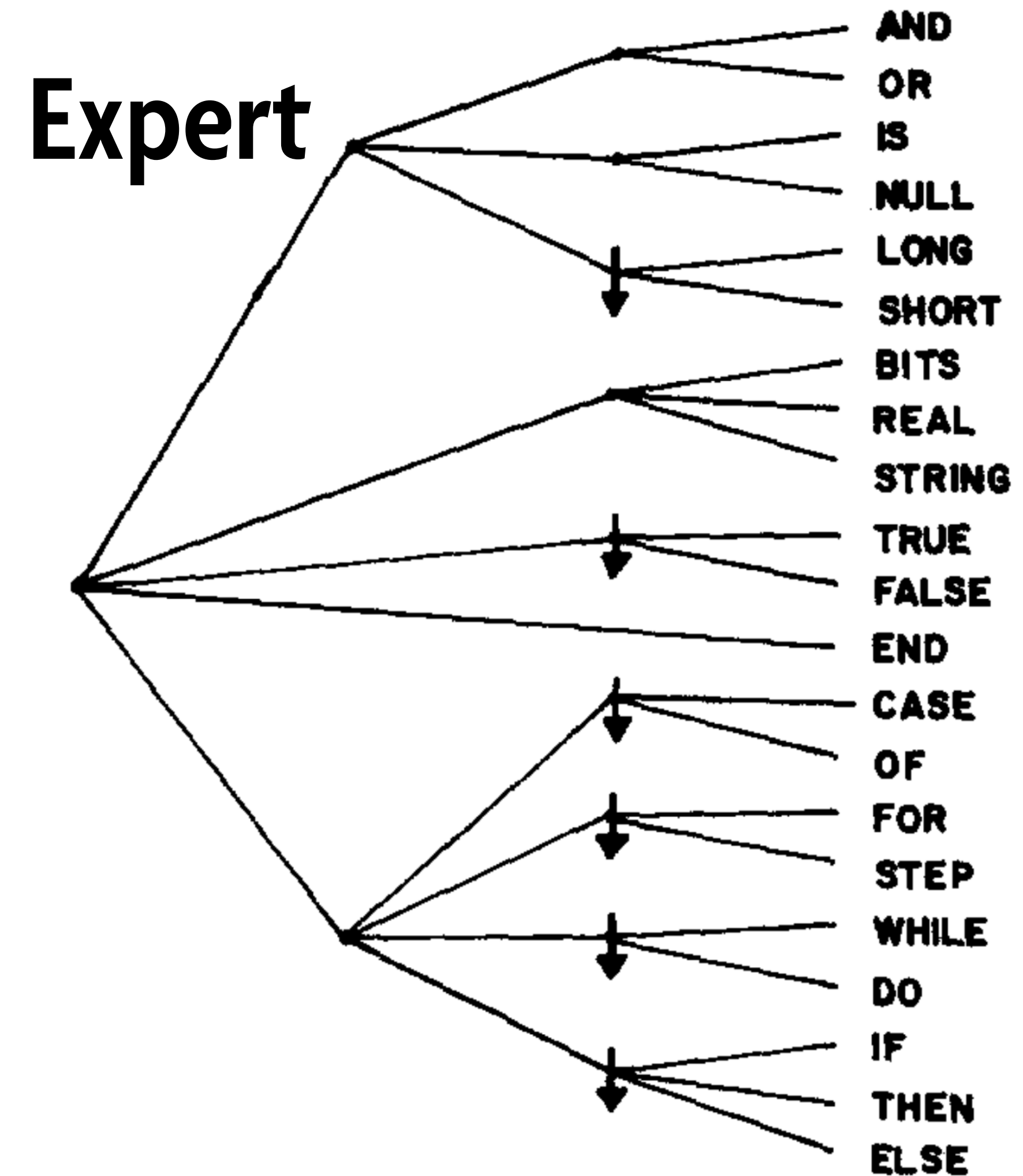
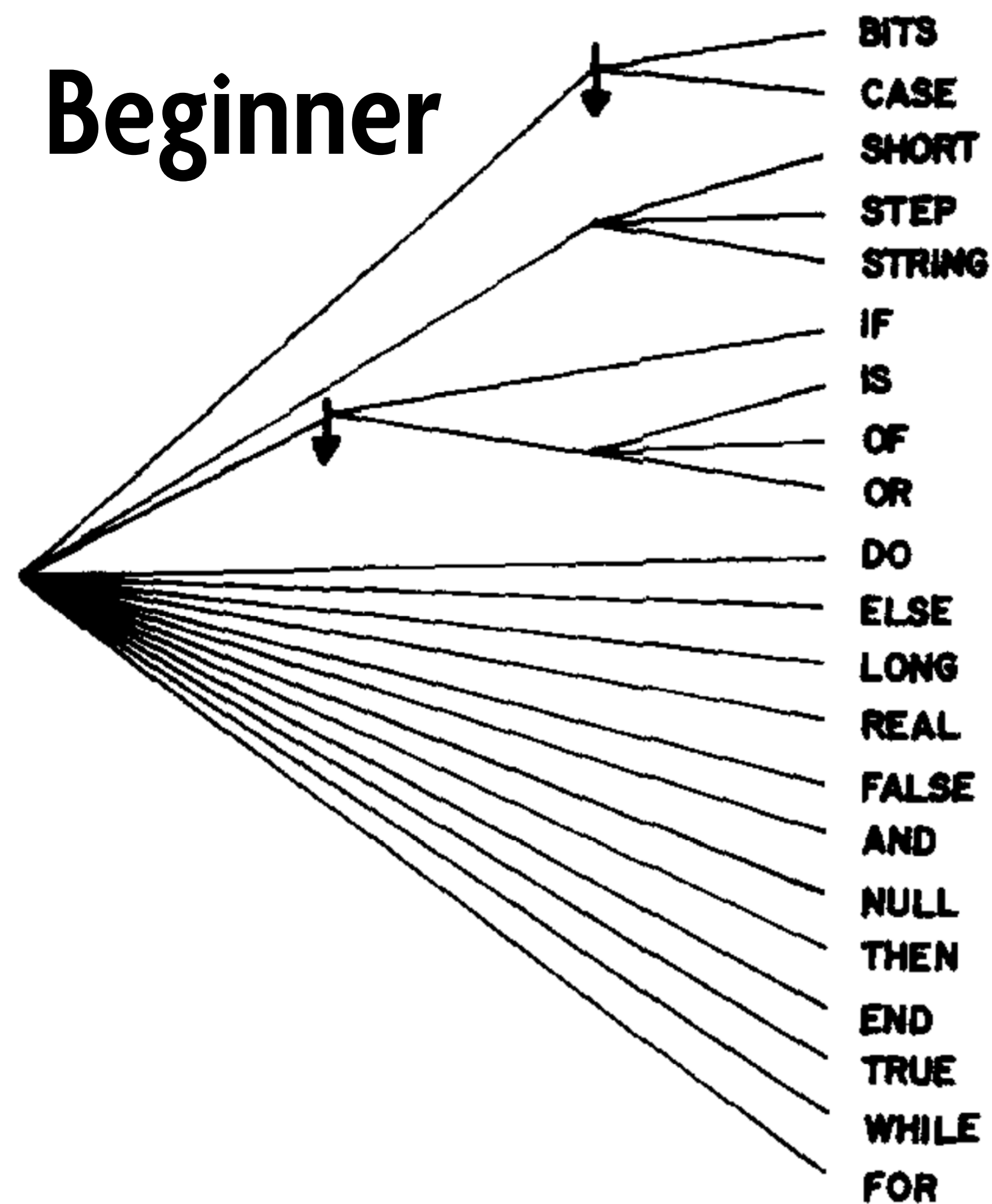


... [21 cards] ...

Procedure:

1. Memorize keywords until perfect recall twice.
2. For 25 times: recall all 21 keywords

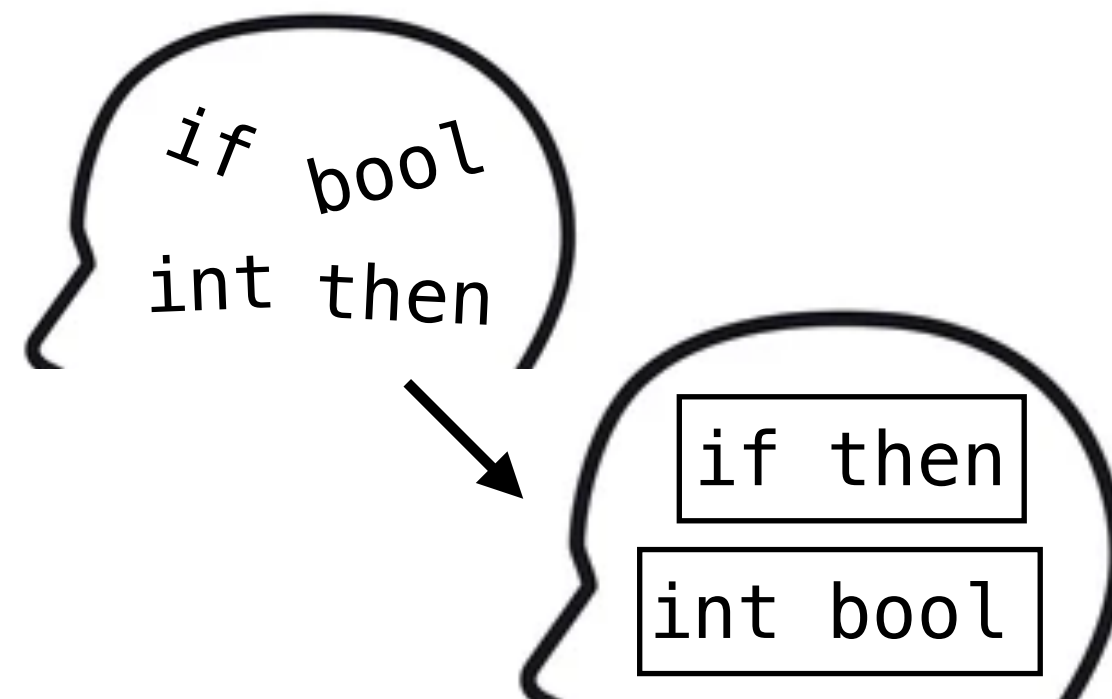
Expert programmers chunk semantically related language keywords



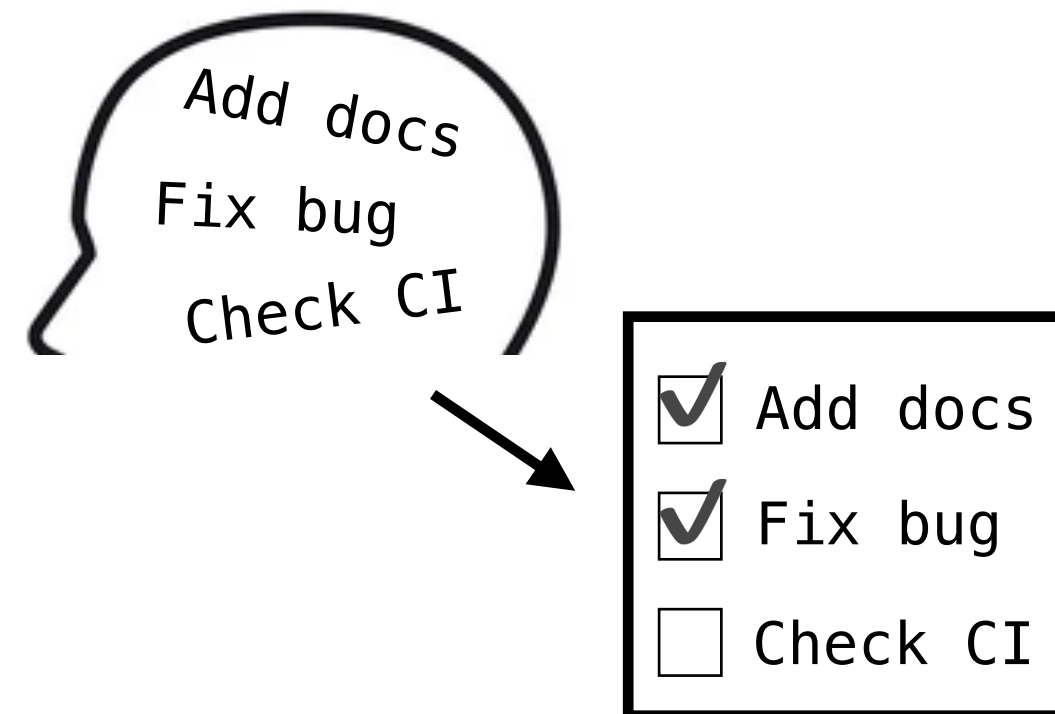
Key observations about working memory

- Working memory is **fragile**: limited capacity (4-10 chunks), easily interfered (competing stimuli), decays quickly (order of seconds)
- **Attention** and **rehearsal** are key to retaining information in working memory & beyond
- A hallmark of skill is efficient use of working memory by compacting related information into **chunks**

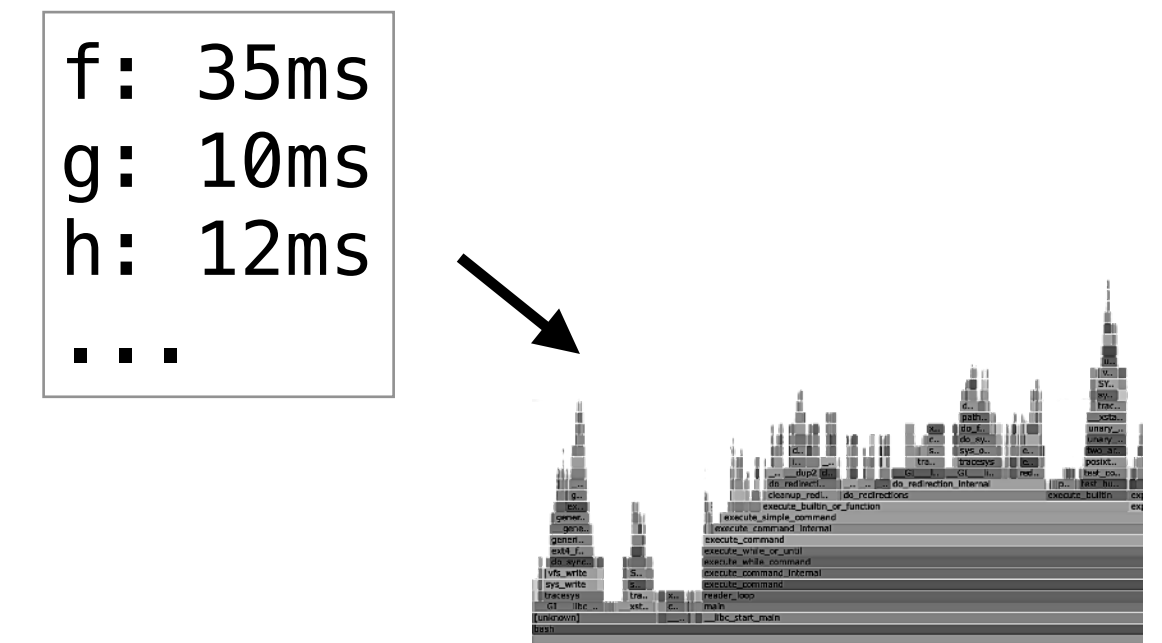
Chunk



Externalize



Visualize



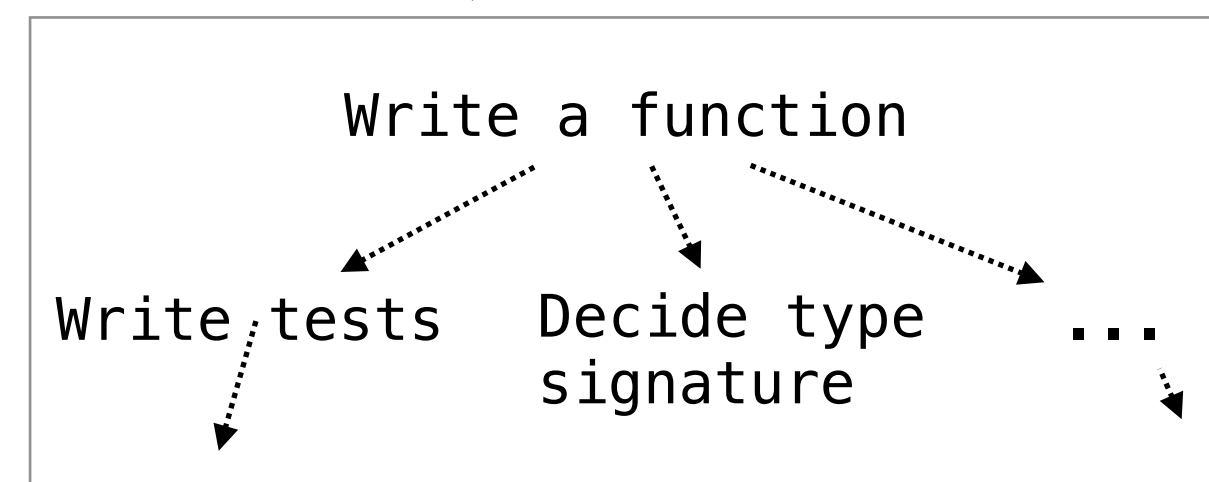
How do we overcome our terrible working memory?

```
f = open('foo.txt', 'r')
for s in f.read().split('\n'):
    print(s)
f.close()
```

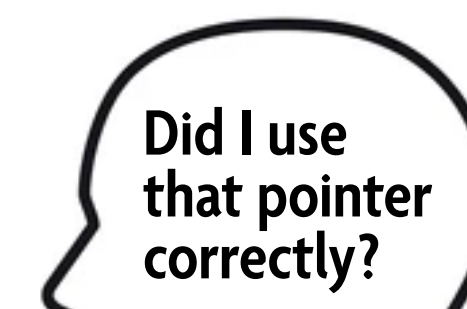
```
with open('foo.txt', 'r') as f:
    for s in f.readlines():
        print(s)
```

Schematize

Write the whole function



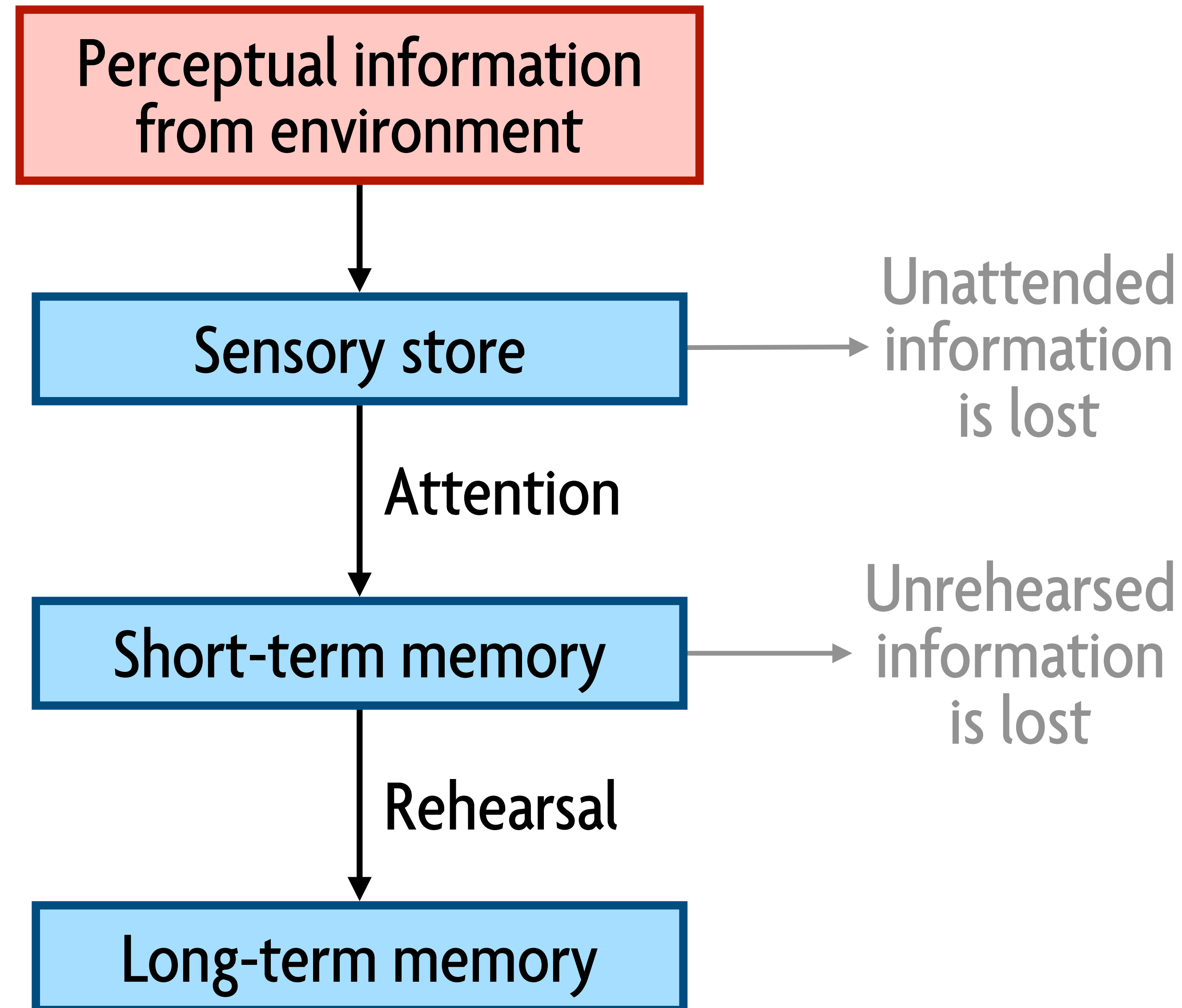
Decompose



```
error[E0597]: `x` does not live long enough
--> test.rs:4:5
2 |     let z = {
3 |         - borrow later stored here
4 |         let x = 1;
5 |         &x
   |         ^^ borrowed value does not live long enough
6 |     };
   |     - `x` dropped here while still borrowed
```

Automate

A basic model of memory



Long-term memories form upon repeated exposure

Materials

The <PROFESSION> <VERB> the <PROFESSION>

“The doctor hated the lawyer”

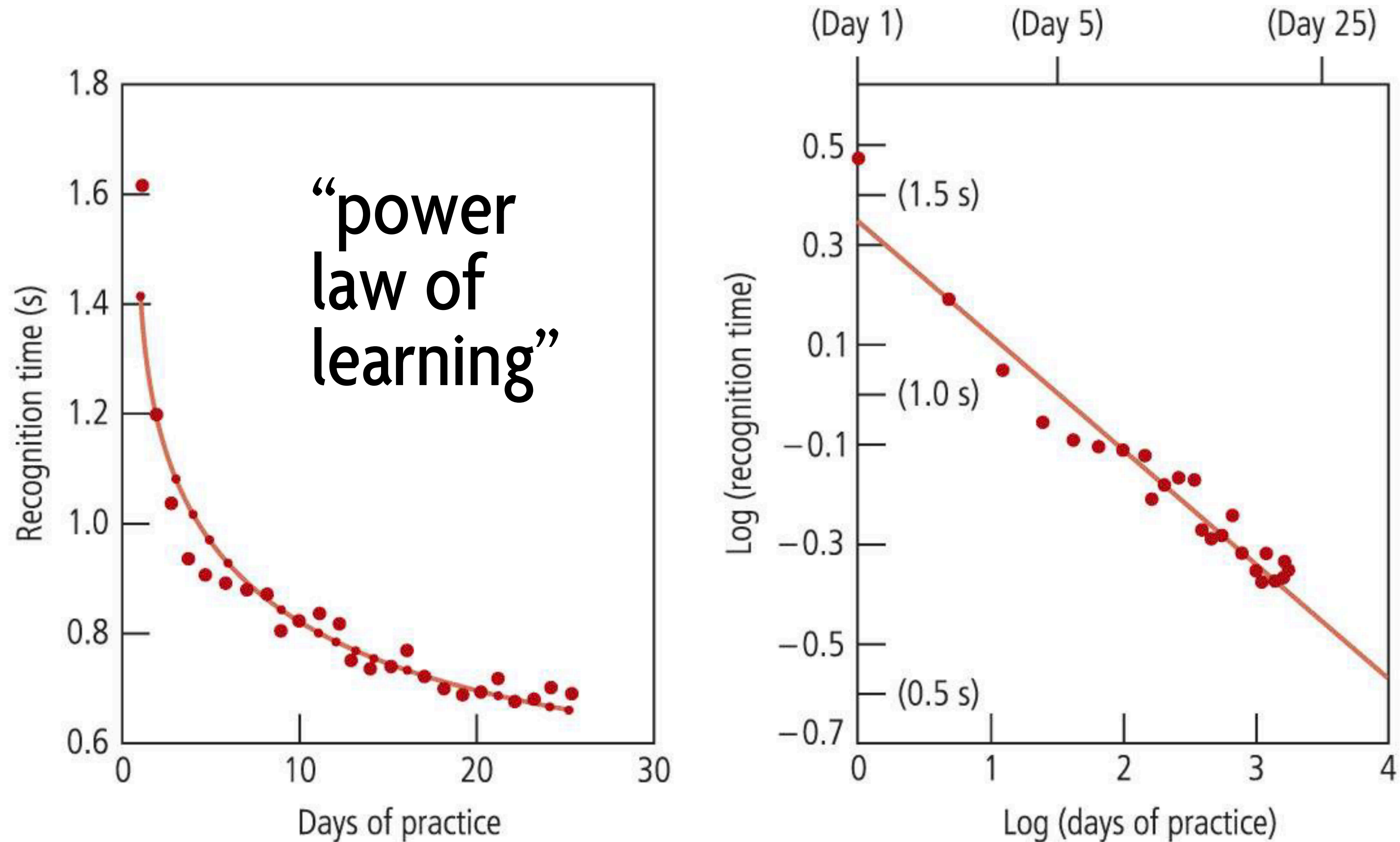
“The nurse hired the doctor”

... [16 sentences] ...

Procedure

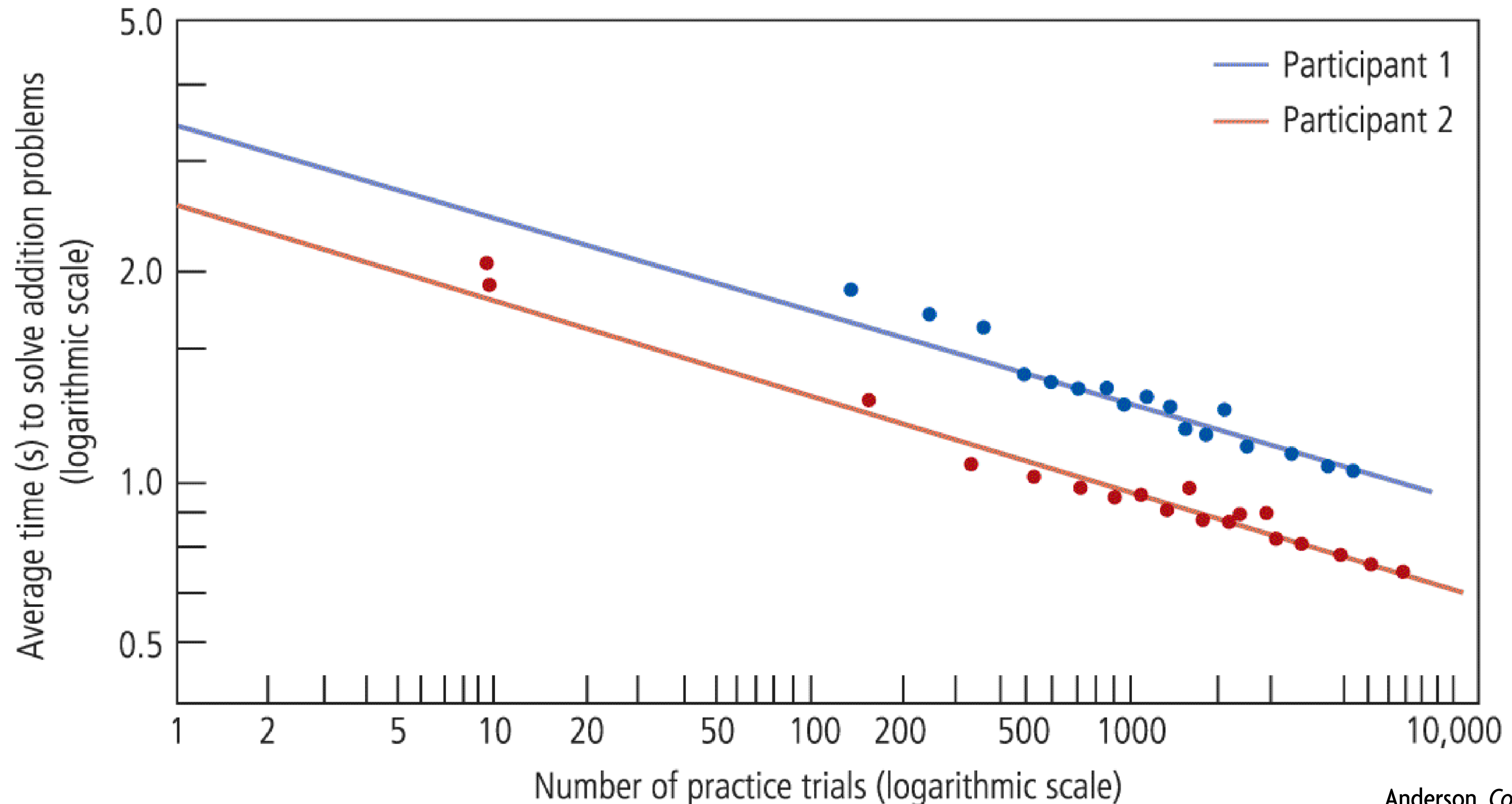
- (1) study the sentences, (2) Cloze test until 100% correct,
- (3) measure reaction time of yes/no recognition

Long-term memories form upon repeated exposure



Power law of learning extends quite far

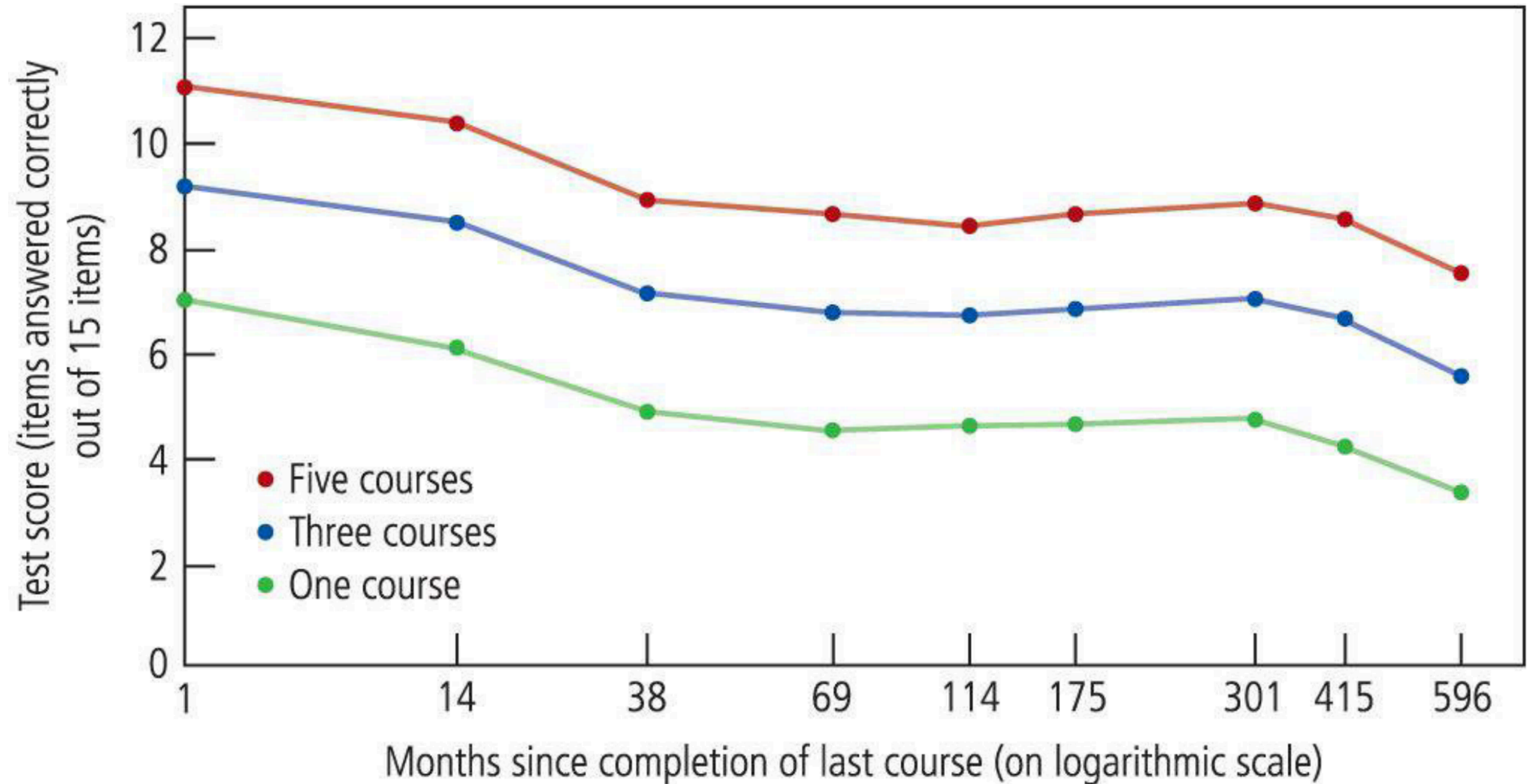
“the effects of practicing addition problems for 10,000 trials by two participants”



Anderson. *Cognitive Psychology*. 2020

Blackburn. “Acquisition of Skill: An Analysis of Learning Curves” 1936

Memory decays diminishingly over time



Anderson. *Cognitive Psychology*. 2020

Bairick. "Semantic memory content in permastore: Fifty years of memory for Spanish learned in school" 1984

Massing improves short-term retention, spacing improves long-term retention

Materials:

104 Japanese-English
word pairs, e.g.

door — tobira

bird — tori

fish — sakana

rain — ame

...

Procedure:

Study: door — tobira

Study: bird — tori

[... 2, 14, 98 trials later...]

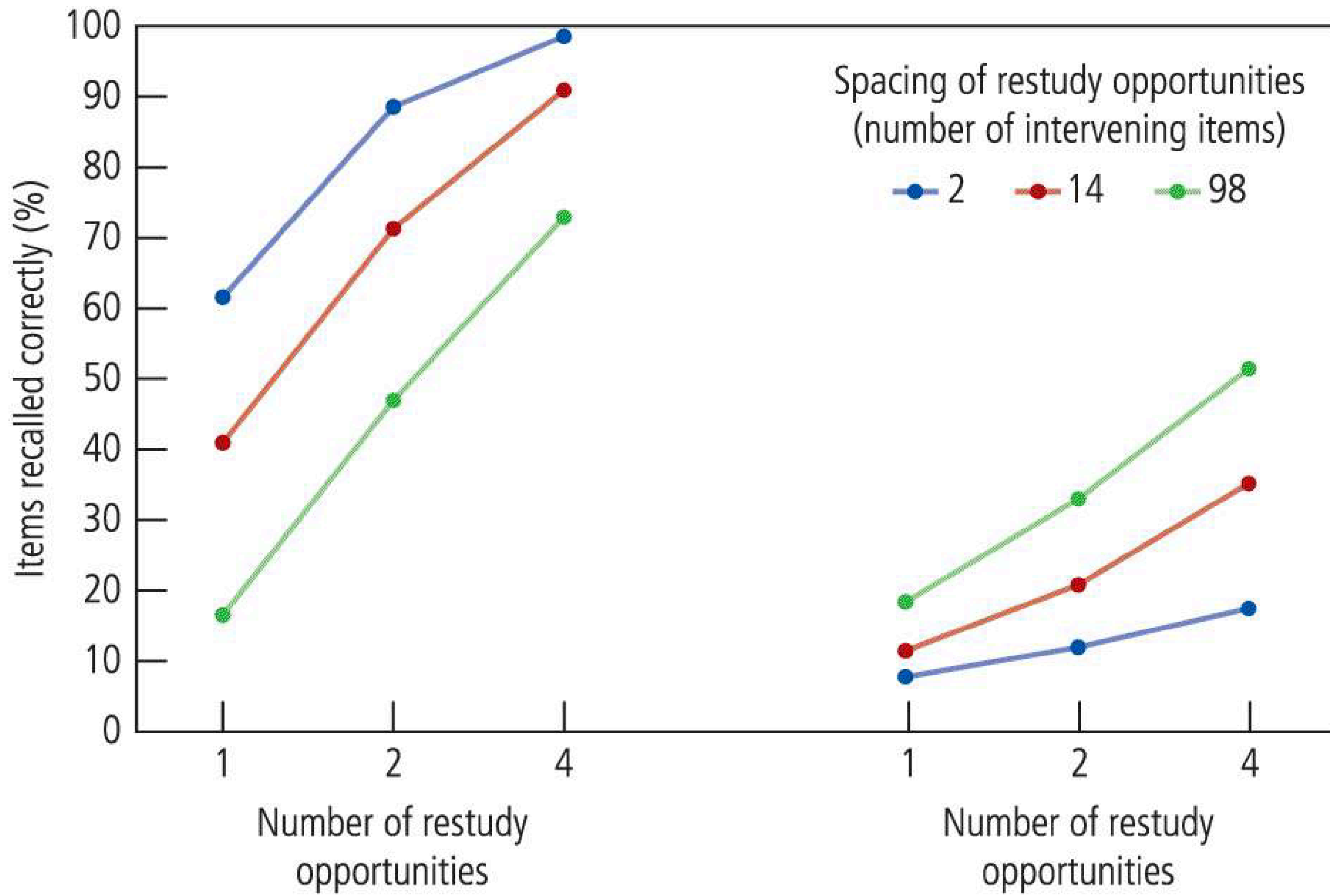
Test: tobira — ?

— **bird**

Restudy: door — tobira

Test: fish — sakana

[... each pair
tested 1, 2, or
4 times ...]



(a) Results of last test on first day

(b) Results of first test on next day

Next lecture:
spaced repetition systems!

In the meantime:
what makes thoughts memorable?

Recognition task is easier than recall task

Materials:

600 common English words

For each participant:

- Randomly partition into 540 training words and 60 negative test words
- Random sample 60 positive test words from 540
- Pair positive and negative words into test items

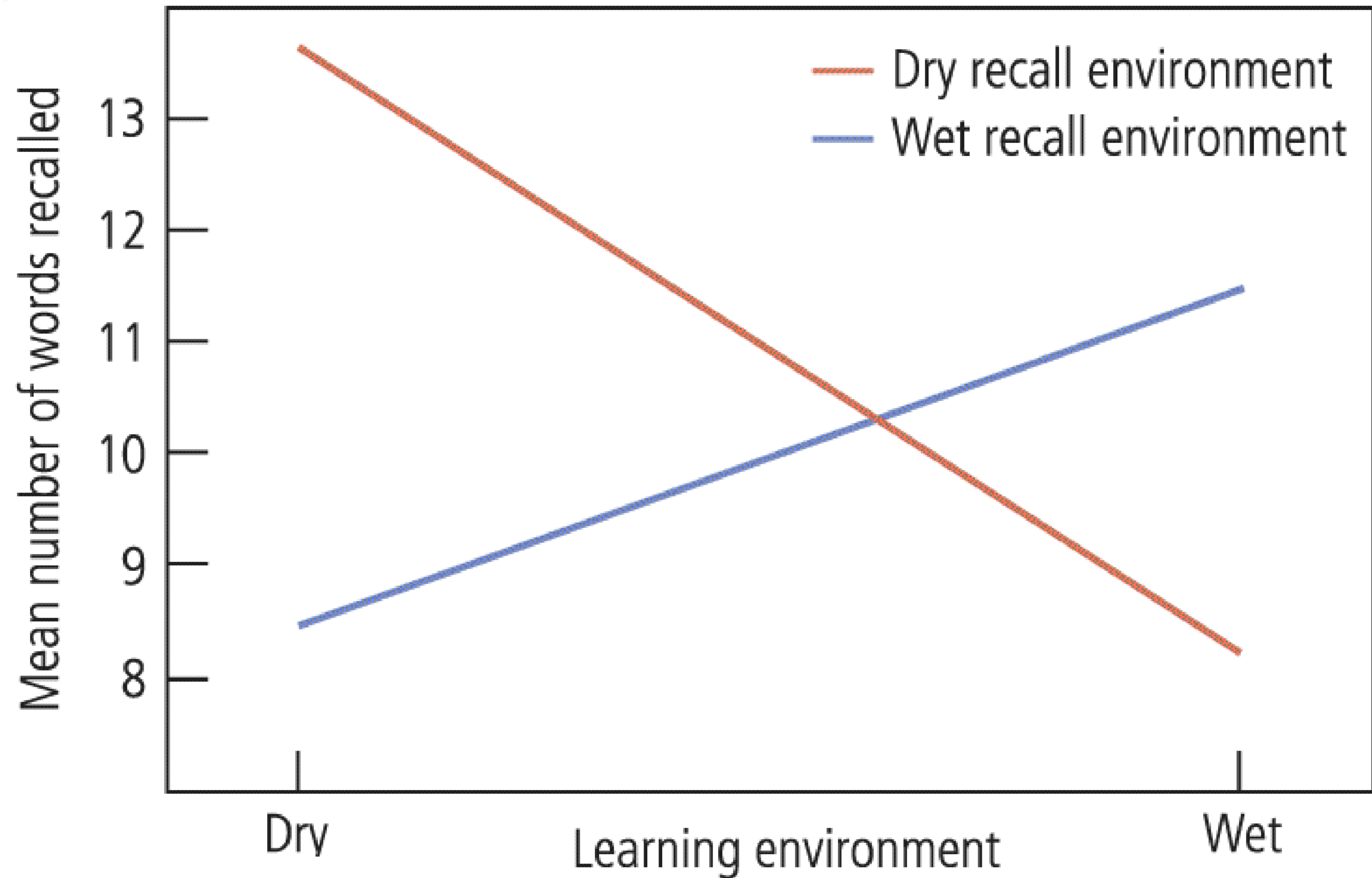
Procedure:

- Read through training deck of 540 words
- For each test item, guess which word is positive

Results: median 90% correct
(88% for sentences, 98% for pictures)

Context can strengthen recall

Procedure: memorize words [underwater, on land] and recall [underwater, on land]



...But not all context strengthens recall

Procedure: randomly assign undergraduates to take psych/CS/anthro exams in lecture room or different room

Results: no measurable effect on grades

Lessons from oral tradition and “artificial memory”

Orality and literacy produce different discursive structures

New American Bible (1970)

In the beginning,
when God created the heavens and the earth,
the earth was a formless wasteland,
and darkness covered the abyss,
while a mighty wind swept over the waters.
Then God said, 'Let there be light',
and there was light.

Douay Bible (1610)

In the beginning
God created heaven and earth.
And the earth was void and empty,
and darkness was upon the face of the deep;
and the spirit of God moved over the waters.
And God said: Be light made.
And light was made.

1. Concrete and Imagistic

Oral traditions prefer concrete, imagistic, and agonistic language

"The angles of a triangle are equal to two right angles."

VS.

"The triangle stood firm in battle, astride and poised on its equal legs, fighting resolutely to protect its two right angles against the attack of the enemy,"

Mind palaces originated $\geq 2,000$ years ago



“For the places are very much like wax tablets or papyrus, the images like the letters, the arrangement and disposition of the images like the script, and the delivery is like the reading.”

“give each fifth *locus* some distinguishing mark”

“form one's memory *loci* in a deserted and solitary place”

“too many intercolumnar spaces are not good”

“The interveals between the *loci* should be of moderate extent, perhaps about thirty feet”

Ad Herennium, orig. circa 85 BCE

2. Poetic and Musical

Poetics limit choice and cue memory

Rhyme

There once was a man from **Peru**
Who dreamed he was eating his **shoe**
He woke with a **fright**
In the middle of the **night**
To find that his dream had come **true**

Alliteration

Ma be rí rofesser
recht flatho,
fothuth iar miad,
mesbada slóg
sabaid cuirmthige,
cuir mescae;
mess tíre,
tomus forrag,
forberta díri
díthle mesraid;

Poetics limit choice and cue memory

Rhythm

Iambic pentameter

˘ — ˘ — ˘ — ˘ —

But soft, what light through yonder window breaks?

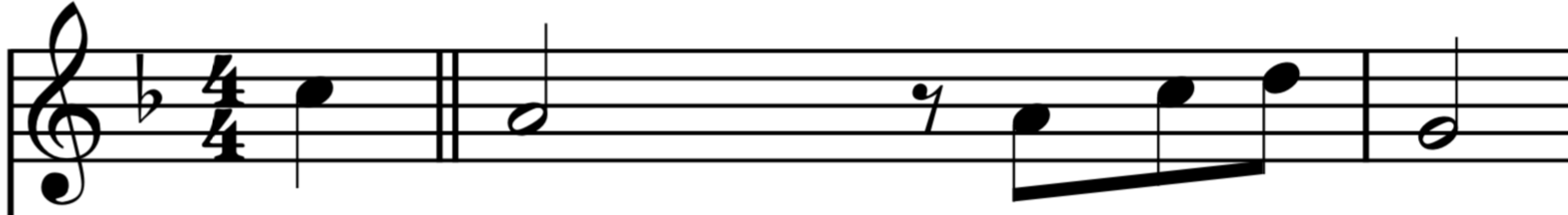
Dactylic hexameter

https://youtu.be/7k7u8XeTG0U?si=6RR-9tfI3pug00S_&t=4

Music reinforces language in parallel

Minor third

Perfect fourth



Hey Jude, don't make it bad,

The image shows a musical staff in 4/4 time with a key signature of one flat (Bb). The melody for 'Hey Jude' is written. Above the staff, the interval between the first two notes (F4 and Ab4) is labeled 'Minor third' in red. The interval between the third and fourth notes (Bb4 and Eb5) is labeled 'Perfect fourth' in red. The lyrics 'Hey Jude, don't make it bad,' are written below the staff. The notes are: F4 (quarter), Ab4 (quarter), Bb4 (quarter), Eb5 (quarter), and Eb4 (half).

3. Repetitive and Cliché

Scripts: patterns of action

Excerpts from the *Iliad*

As for now a black ship let us draw
down to the great salt sea

And therein oarsmen let us advisedly
gather and thereupon a hecatomb

Let us set and upon the deck Chryseis
of fair cheeks

Let us embark. And one man as captain,
a man of counsel, there must be.

The son of Atreus a swift ship to the salt sea
drew down

And therein oarsmen he selected twenty and
thereupon a hecatomb

He embarked for the god and on the deck
Chryseis of the fair cheeks

He set having brought her. And therein a
captain went, even Odysseus of many counsels

Oral tradition is concrete, imagistic, poetic, musical, repetitive, and cliché

- Concrete images are more memorable than abstract statements
- Poetics and music constrain choice, cue recall, and strengthen associations through overlapping signal
- Repetition and cliché strengthen memory, permit reuse of narrative schema
- **Q:** what are the implications for tools for thought?