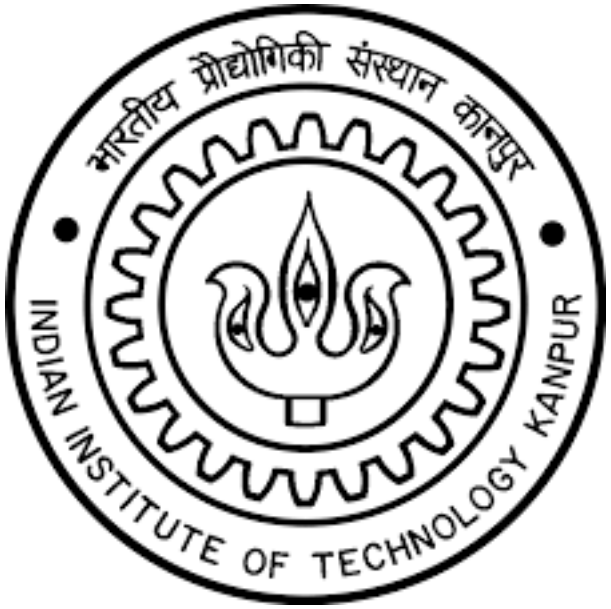

Indian Institute of Technology
Kanpur

In Collaboration
with

National Program on Technology Enhanced Learning (NPTEL)

Presents

Course Title:

Basic Cognitive Processes

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Lecture 30: Memory - II

Short - term Memory

- **Short - term memory (STM)** is the system involved in storing small amounts of information for a brief period of time (Baddeley et al., 2009).

- Duration of Short - Term Memory
  - Brown (1958), and Peterson & Peterson (1959) used the method of recall to determine the duration of STM.
  - In their experiments, participants were given a task similar to one here:

I will say some letters and then a number. Your task will be to remember the letters. When you hear the number, repeat it and begin counting backwards by 3s from that number. For example, if I say ABC 309, then you say 309, 306, 303, and so on, until I say "Recall." When I say "Recall," stop counting immediately and say the three letters you heard just before the number.

Excerpt from: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. Publishing

Start with the letters and number in trial 1 below. It is important that the person count out loud because this prevents the person from rehearsing the letters. Once the person starts counting, time 20 seconds, and say "recall." Note how accurately the person recalled the three letters and continue to the next trial, noting the person's accuracy for each trial.

Trial 1:	F Z L	45
Trial 2:	B H M	87
Trial 3:	X C G	98
Trial 4:	Y N F	37
Trial 5:	M J T	54
Trial 6:	Q B S	73
Trial 7:	K D P	66
Trial 8:	R X M	44
Trial 9:	B Y N	68
Trial 10:	N T L	39

Excerpt from: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (p. 124).

- Peterson & Peterson also did a similar experiment in which they varied the time between when they said the number and when the participant began recalling the letters.
- Peterson & Peterson found that their participants were able to remember about 80% of the letters after counting for 3 seconds but could remember an average of only 12% of the three letter groups after counting for 18 seconds.
- They interpreted this result as demonstrating that participants forgot the letters because of **decay**; i.e. their memory decayed because of the passage of time after hearing the letters.

- However, when Keppel & Underwood (1962) looked more closely at the results, they found that if they considered the participant's performance on just the first trial, there was little *fall - off* between the 3 second & the 18 second delay.

- Why would memory worsen after a few trials?

  - Keppel & Underwood suggested that the drop - off in memory was due not to decay of the memory trace, Peterson & Peterson had proposed, but due to **proactive interference -** interference that occurs when information that was learned previously interferes with learning new information.

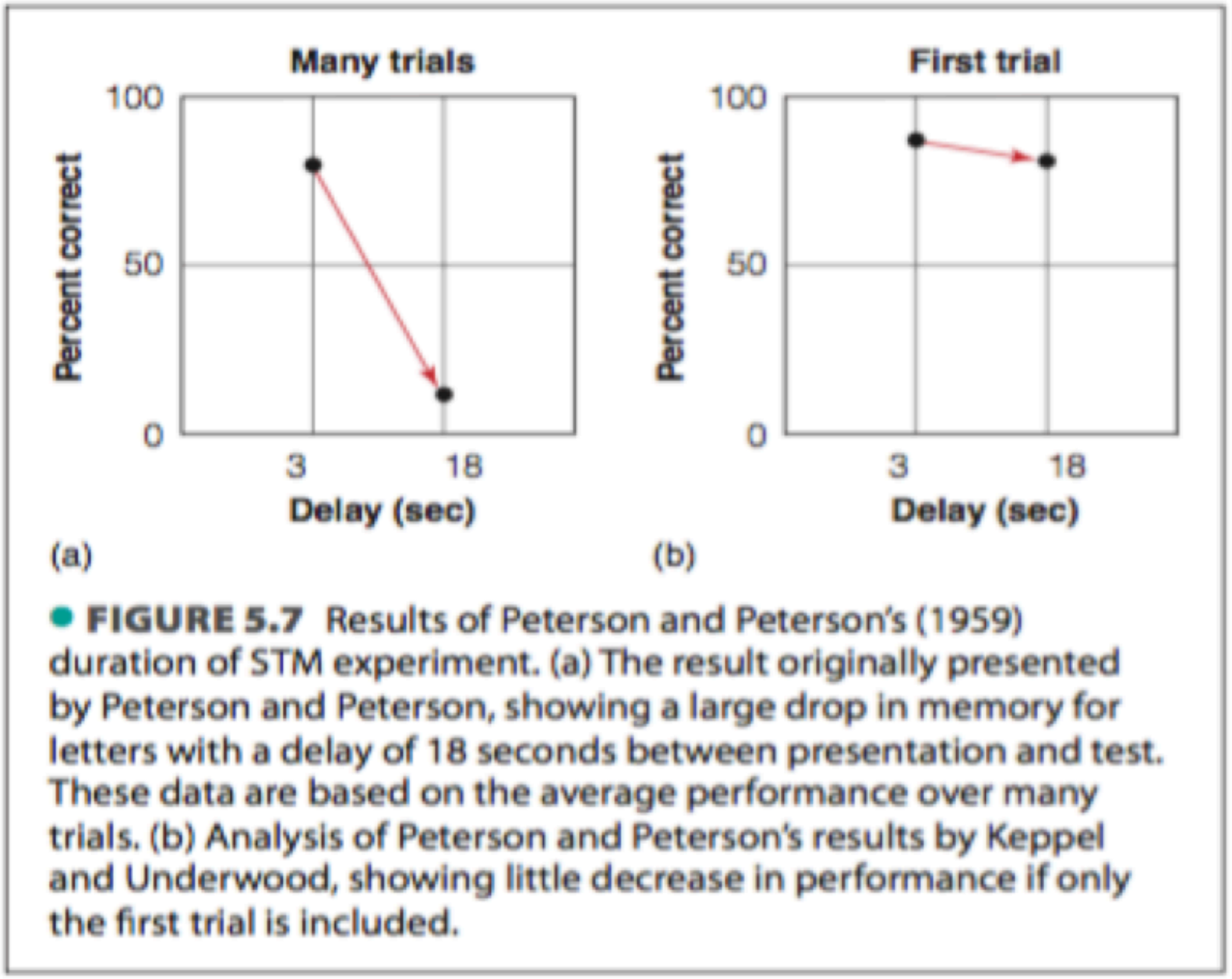

FIGURE 5.7 Results of Peterson and Peterson's (1959) duration of STM experiment. (a) The result originally presented by Peterson and Peterson, showing a large drop in memory for letters with a delay of 18 seconds between presentation and test. These data are based on the average performance over many trials. (b) Analysis of Peterson and Peterson's results by Keppel and Underwood, showing little decrease in performance if only the first trial is included.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (Fig. 5.7, p. 125).

- Keppel & Underwood proposed that proactive interference is what caused the decrease in memory observed in the later trials of Peterson & peterson's experiment. Thus recalling the early letters in the list created interference that made it more difficult to remember the later letters in the list.

- Another illustration of *proactive interference* is when you try to remember new phone numbers of people who have just changed their number.

- **Capacity of Short - term memory:** there are certainly capacity limits on short - term memory as well. the estimates range between 4 - 9 items.

DEMONSTRATION Digit Span

Using an index card or piece of paper, cover all of the numbers below. Move the card down to uncover the first string of numbers. Read the numbers, cover them up, and then write them down in the correct order. Then move the card to the next string, and repeat this procedure until you begin making errors. The longest string you are able to reproduce without error is your digit span.

2 1 4 9
3 9 6 7 8
6 4 9 7 8 4
7 3 8 2 0 1 5
8 4 2 6 4 1 3 2
4 8 2 3 9 2 8 0 7
5 8 5 2 9 8 4 6 3 7

If you succeeded in remembering the longest string of digits, you have a digit span of 10 or perhaps more. The typical span is between 5 and 8 digits.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (p. 125).

- According to the measurements of digit span, the average capacity of STM is about 5 - 9 items, i.e. about the length of a phone number.

- This idea was initially proposed by George Miller (1956) in a famous paper titled, “The Magical Number Seven, Plus or Minues Two”.

- More recent measures of STM capacity have set the capacity at about 4 items (Cowan, 2001). This conclusion was based on the results of experiments like the one by Luck & Vogel (1997), which measured the capacity of STM by flashing two arrays of coloured squares separated by a brief delay.

- The participant's task was to indicate whether the second array was the same or different from the first array.

- On trials in which the second row was different, the colour of one square was changed

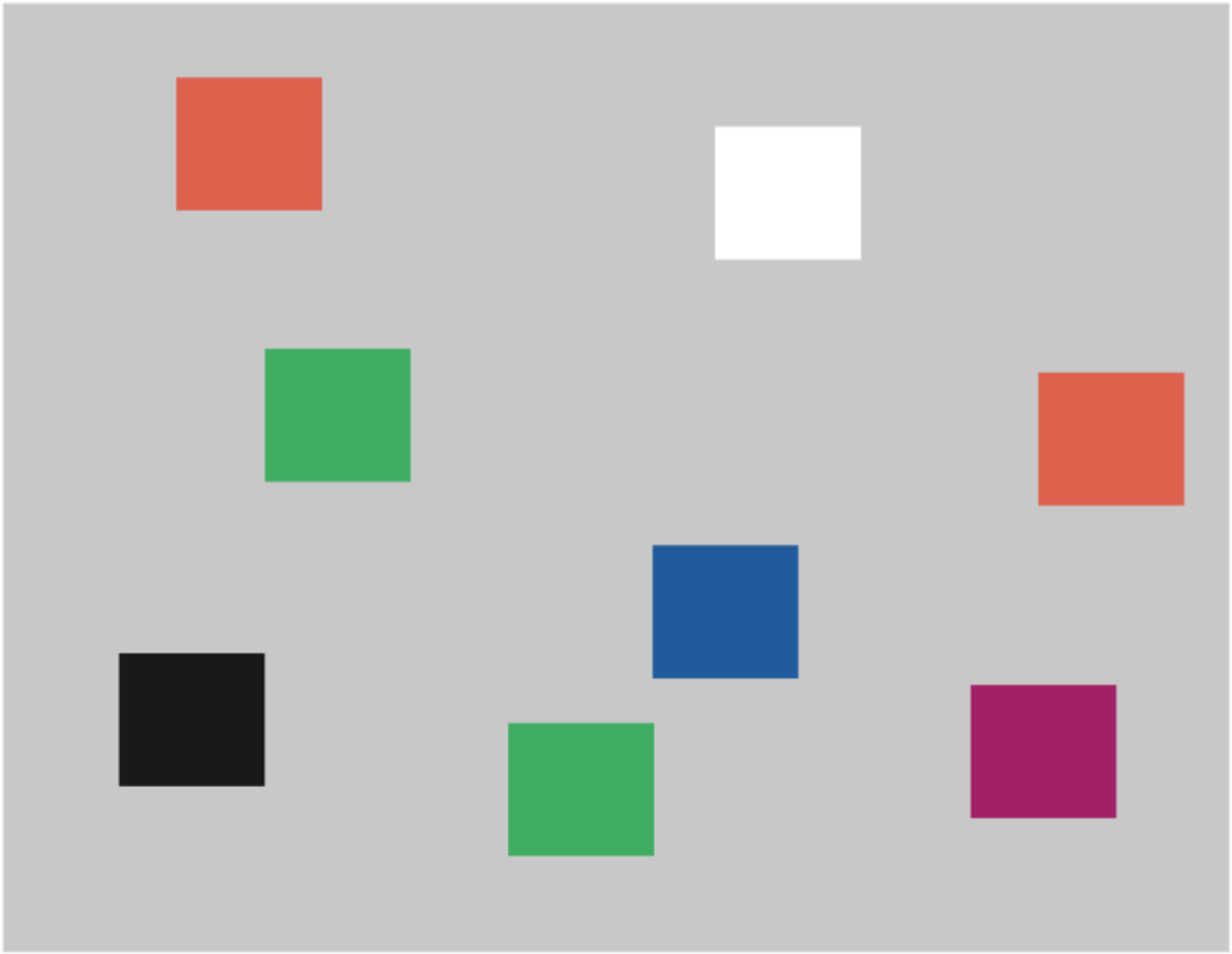

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.8, p. 126).

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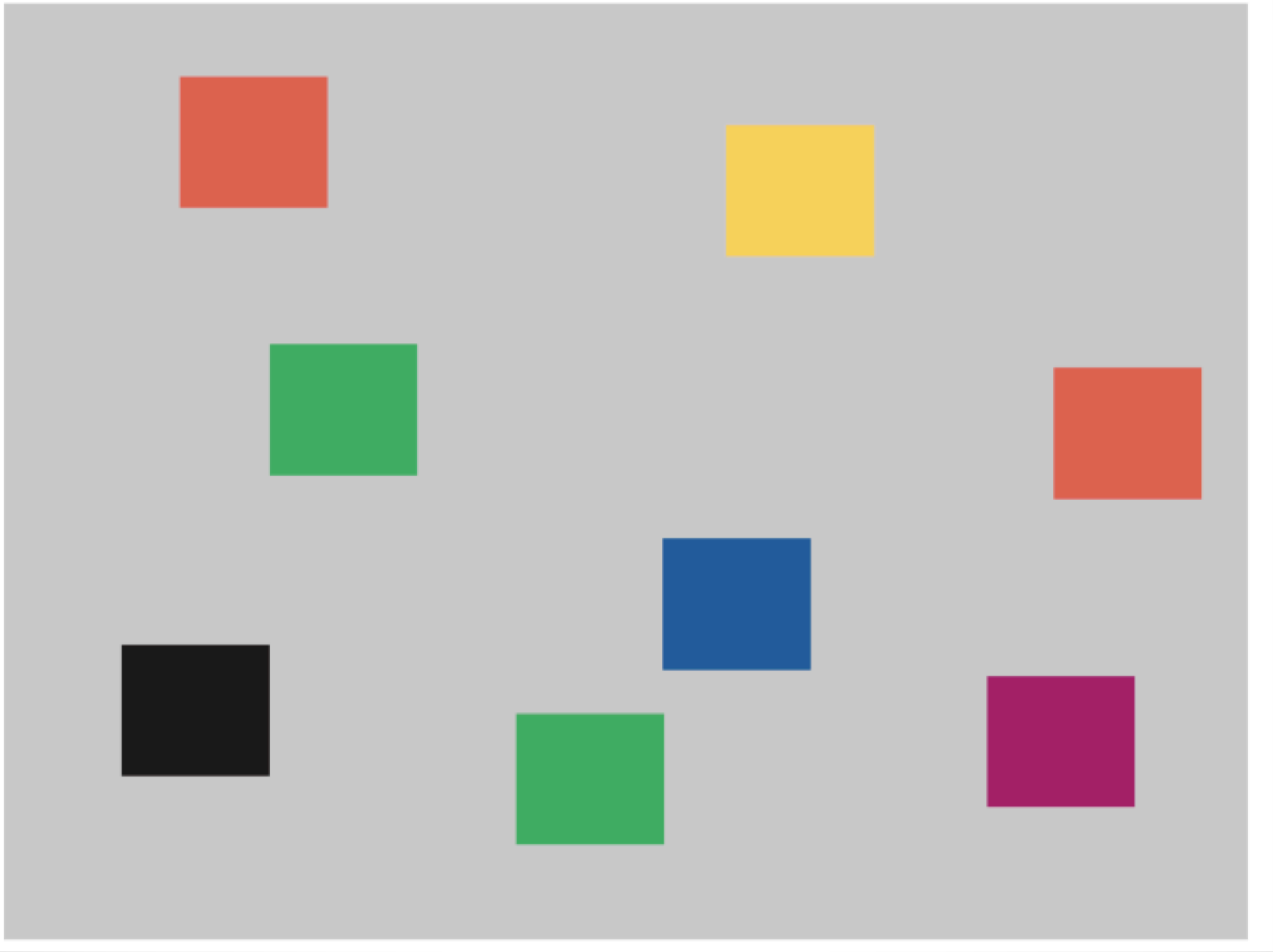

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- The result of this experiment shows that performance was almost perfect when there were 1 to 3 squares in the arrays, but that performance began decreasing when there were more than 4 squares.

- Luck & Vogel (1997) concluded from this result that participants were able to retain about 4 items in their short - term memory.

- Other experiments, using verbal materials, have come to the same conclusion (Cowan, 2001).

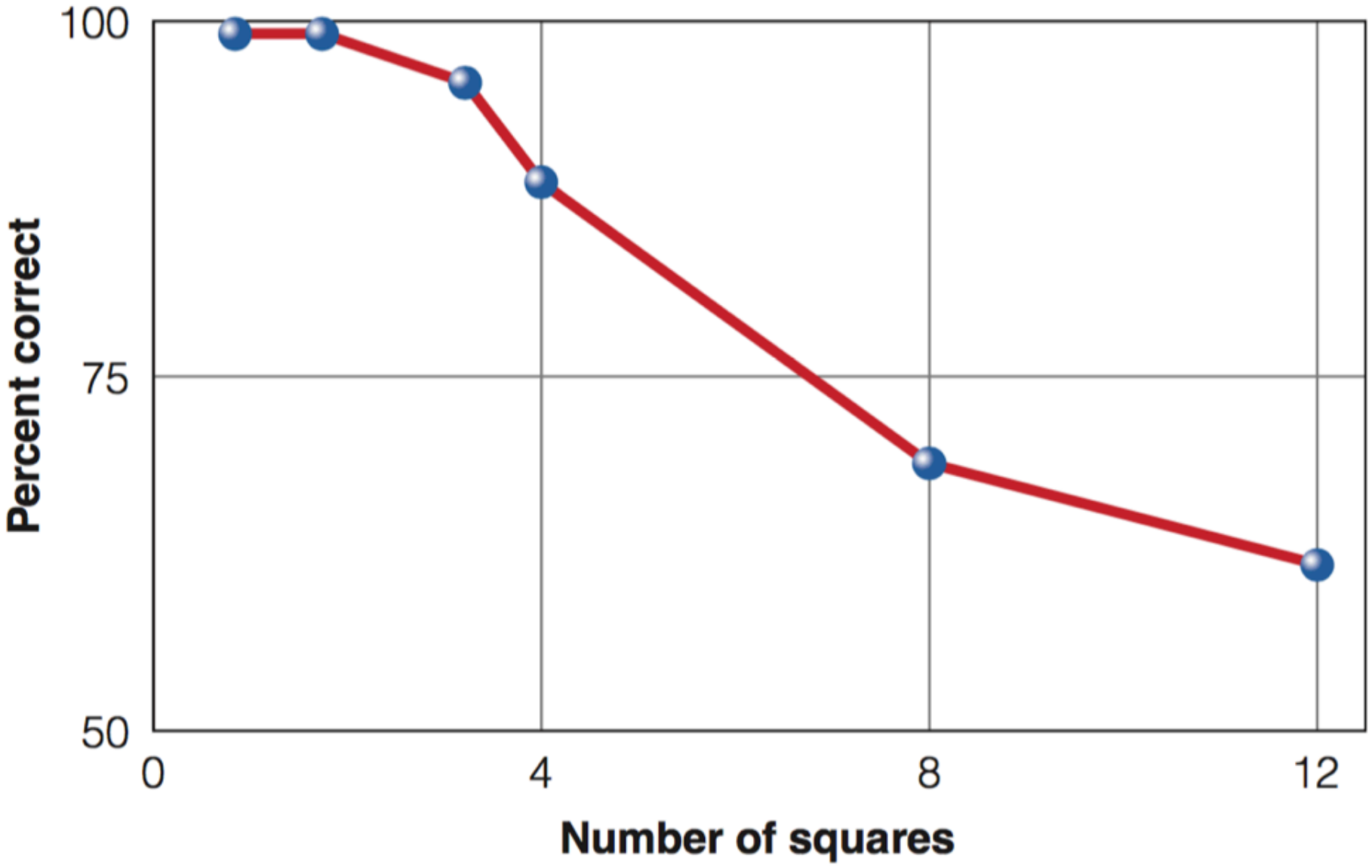


Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.8, p. 126).

- But 4 seems too less, or even 5 or 9, isn't it?
- How do we store much more information that just these numbers?

- **Chunking**: Miller (1956) introduced the concept of chunking to describe the fact that small units (like words) can be combined to larger meaningful units, like phrases, or even larger units like sentences, paragraphs or stories. E.g. if I ask you to learn these words:

- *monkey, child, wildly, zoo, jumped, city, ringtail, young*.

- or these pairs: *ringtail monkey, jumped wildly, young child, city zoo.*

- or these sentence: *The ringtail monkey jumped wildly for the young child at the city zoo.*

- A **chunk** has been defined as a collection of elements that are strongly associated with one another but are weakly associated with elements in other chunks (Cowan, 2001). e.g. ringtail monkey vs ringtail child.

- Thus, chunking in terms of meaning increases our ability to hold information in the STM.

- A similar demonstration is here:

BCIFNCCASICB

CIAFBINBCCBS

- Ericsson & colleagues (1980) demonstrated an effect of chunking by showing how a college student with average memory ability was able to achieve amazing feats of memory.

- Their participant, S.F. had a typical memory span of 7 digits, after extensive training (230 one -hour sessions), he was able to repeat sequences of up to 79 digits without error.

- How?

  - S.F. used chunking to recode the digits into larger units that formed meaningful sequences. e.g. 3492, became 2 minutes and 49 point 2 seconds; near world record mile time.

- another similar example is based on the interaction between the STM & the LTM; provided by an experiment done by Chase & Simon (1973), wherein they showed chess players arrangements of chess pieces taken from actual games; for 5 seconds.

- the chess players were then asked to reproduce the positions they had seen.

- Chase & Simon compared the performance of a chess master who had played or studied chess for more than 10,000 hours to the performance of a beginner who had less than 100 hours of experience.

- the results show that the chess master placed 16 pieces out of 24 correctly on his first try, compared to just 4/24 for the beginner. Also, the master required only 4 trials to reproduce all of the positions exactly, whereas the beginner could not do the same even after 7 trials.

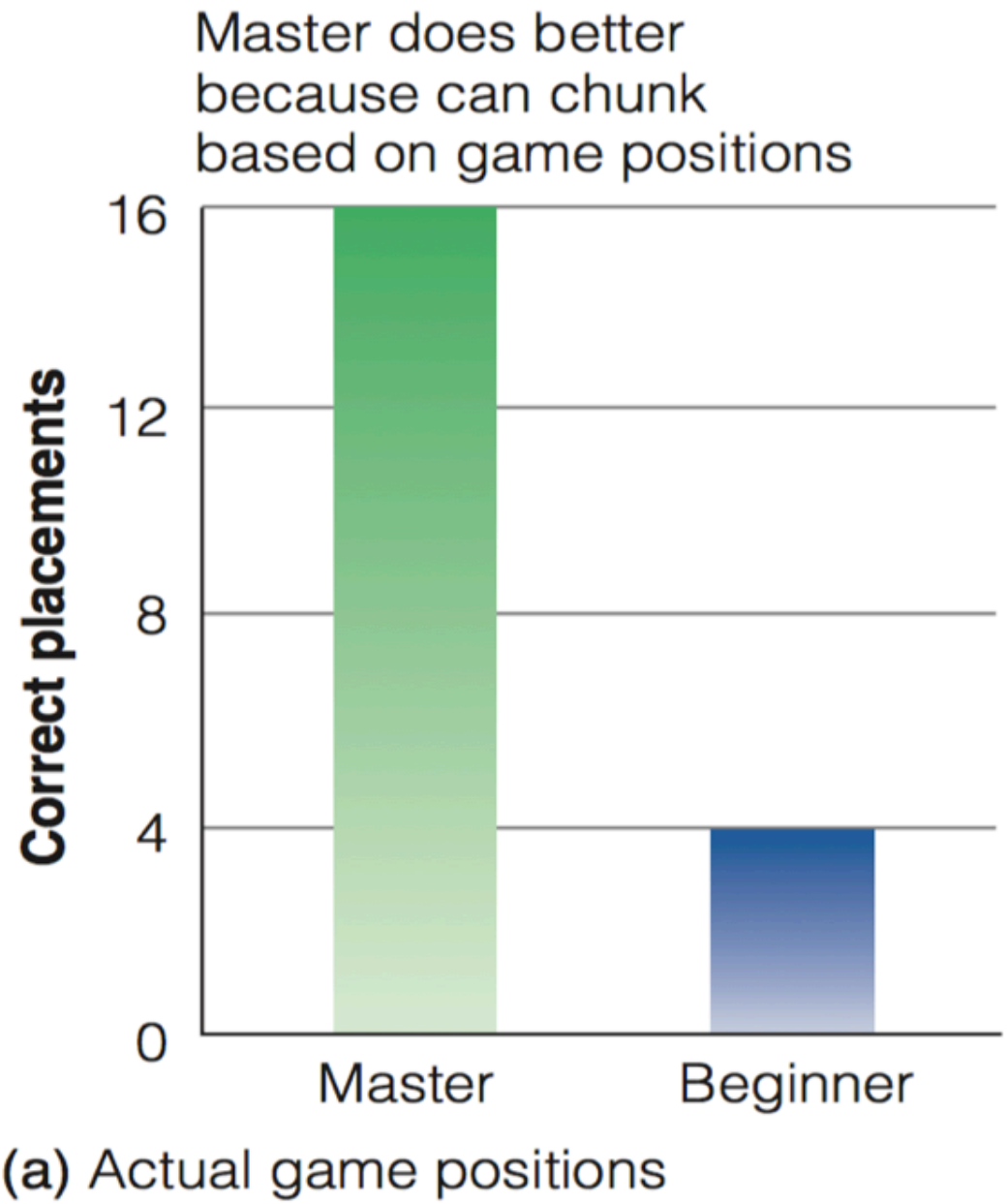


Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.9, p. 127).

- So, does the master have better STM than the beginners?
- Chase & Simon answered this question by testing the ability of masters & beginners to remember random arrangements of the chess pieces.
- When the pieces were arranged randomly, the familiar patterns were destroyed, and the chess master's advantage vanished.

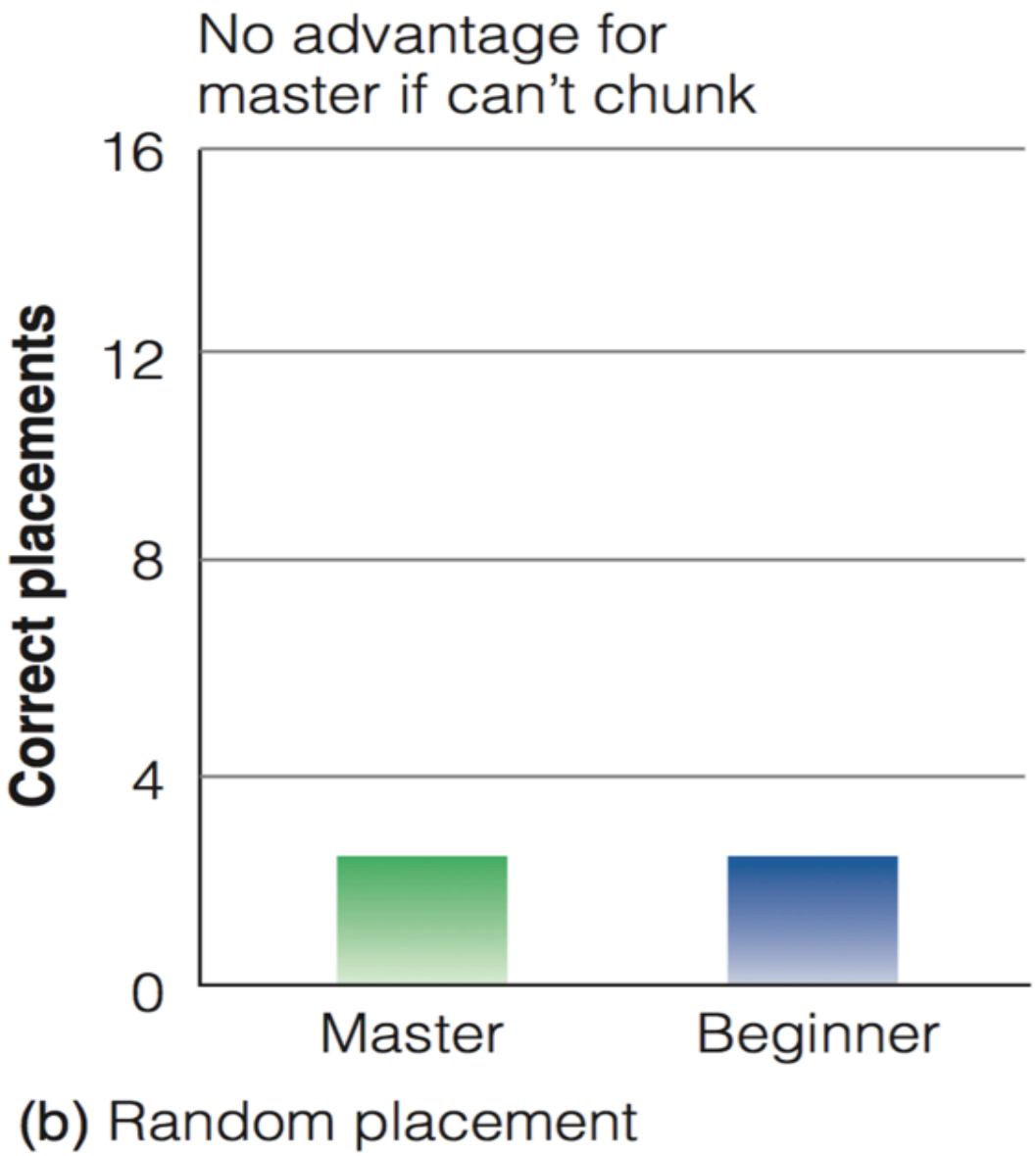


Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (Fig. 5.9, p. 127).

- How is information coded in Short - term Memory?

- **Coding** refers to the way information is represented.

- determining how a stimulus is represented by the firing of neurons is a **physiological approach to coding**.
- we can also take a **mental approach to coding** by asking how a stimulus or an experience is represented in the mind.

- There could be a variety of ways in which one can code information.

- **Auditory Coding** involves representing items in the STM based in their sound.

  - For e.g. in Conrad (1964)'s experiment, participants saw a number of target letters which flashed briefly on a screen and were told to write down the letters in order they were presented.

  - Conrad found that when participants made errors, they were most likely to misidentify the target letter as another letter that **sounded like** the target. e.g. "F" was often misidentified as "S" or "X".

- Conrad concluded that the code for STM ia auditory, rather than visual.

- **Visual Coding** involves representing items visually, as would occur when remembering the details of a floor plan or the layout of streets on a map (Kroll, 1970). This use of visual codes in STM was demonstrated in an experiment by Sergio Della Sala and coworkers (1999), in which participants were presented with a task like:

- Della Sala found that participants were able to complete patterns consisting of an average of 9 shaded squares before making mistakes.

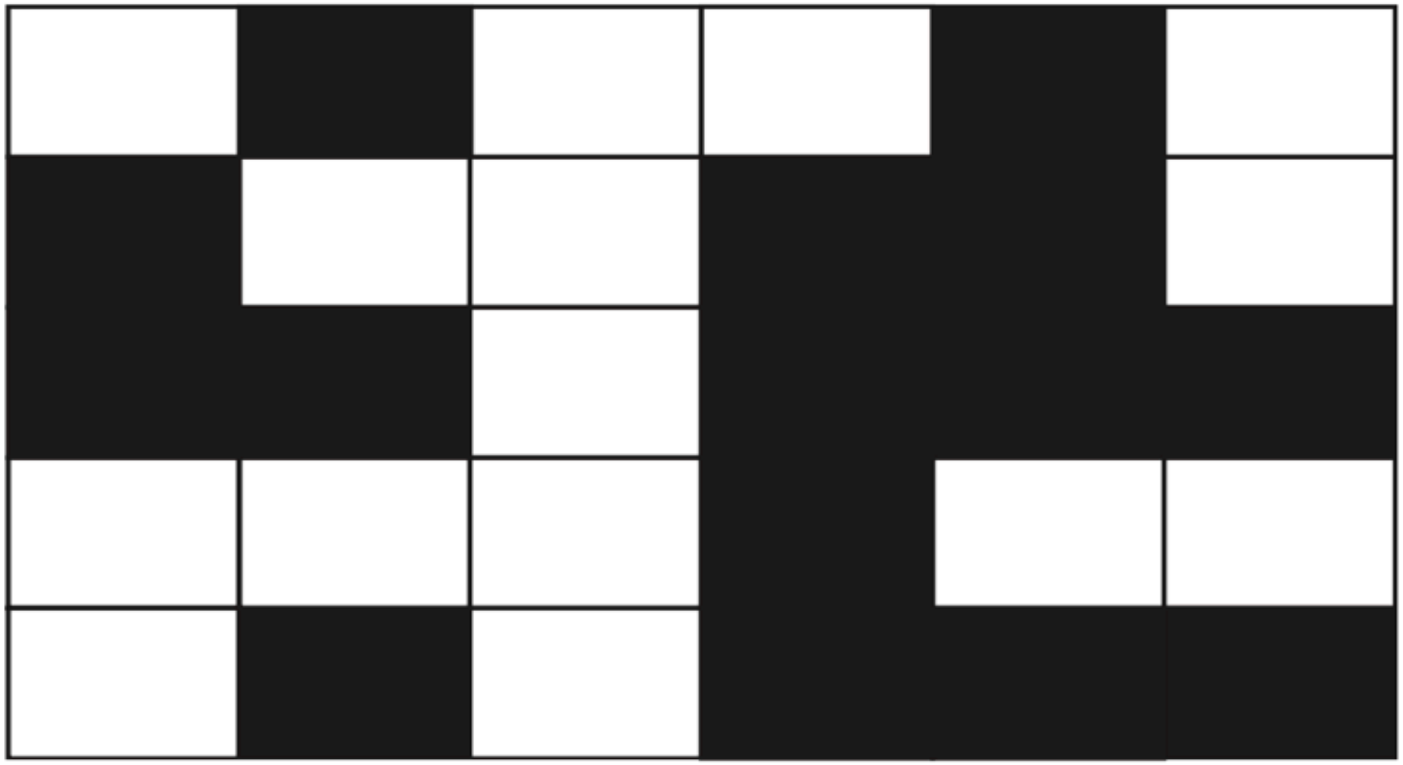


FIGURE 5.10 Test pattern for visual recall test. After looking at this for 3 seconds, turn the page.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.10, p. 128).

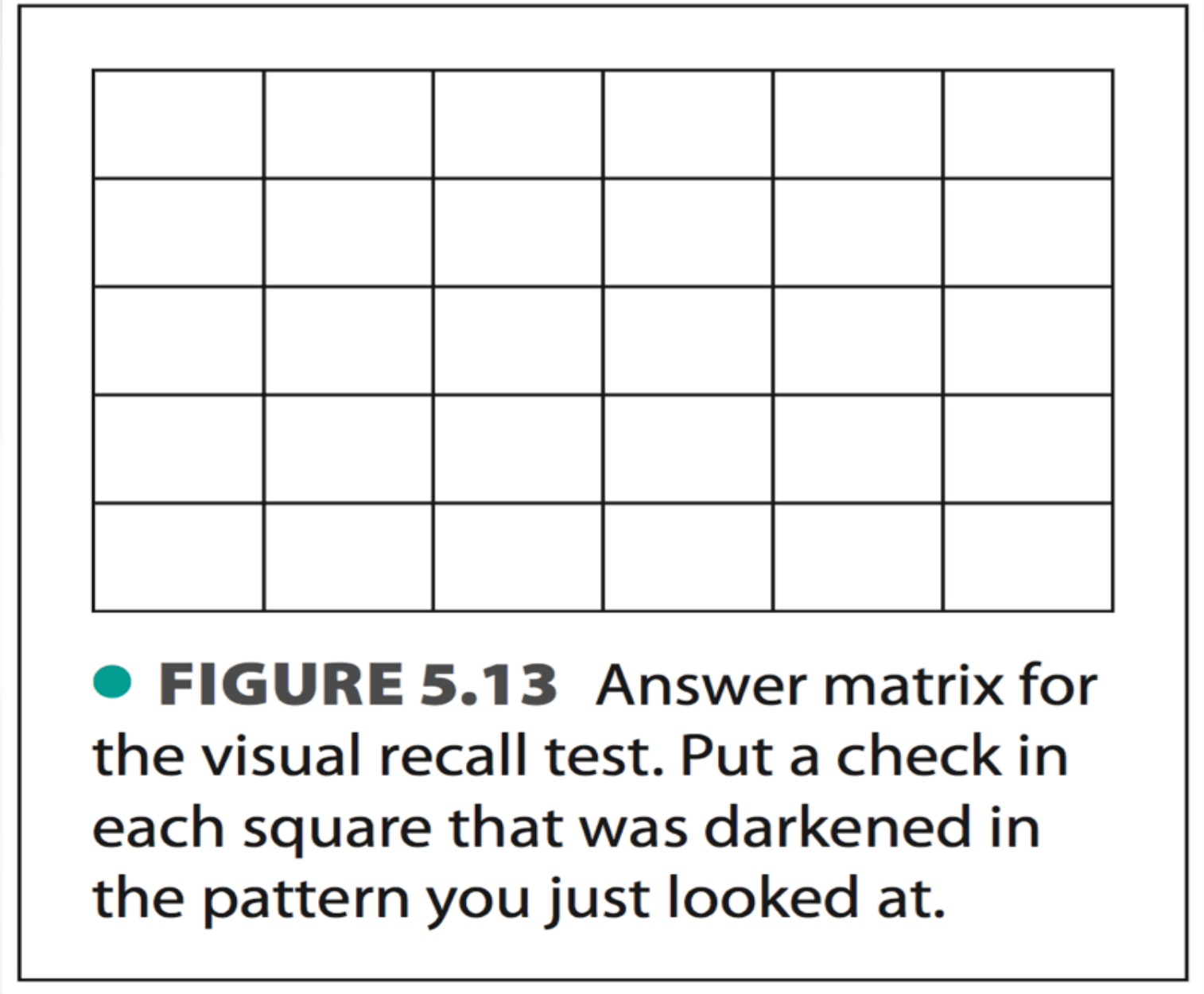


FIGURE 5.13 Answer matrix for the visual recall test. Put a check in each square that was darkened in the pattern you just looked at.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.13, p. 130).

- **Semantic Coding** is representing items in terms of their meaning. An example of semantic coding in STM is provided in an experiment by Wickens et al., (1976).

- On each trial, participants were presented with words related to either a fruit or profession.

- Participants in each group listened to three words for e.g. banana, peach, apple & then counted backwards for 15 seconds and then attempted to recall all the three words. They did this for a total of 4 trials, with different words presented on each trial.

- The basic idea behind this experiment was to create **proactive interference**, by presenting words in a series of trials from the same category.

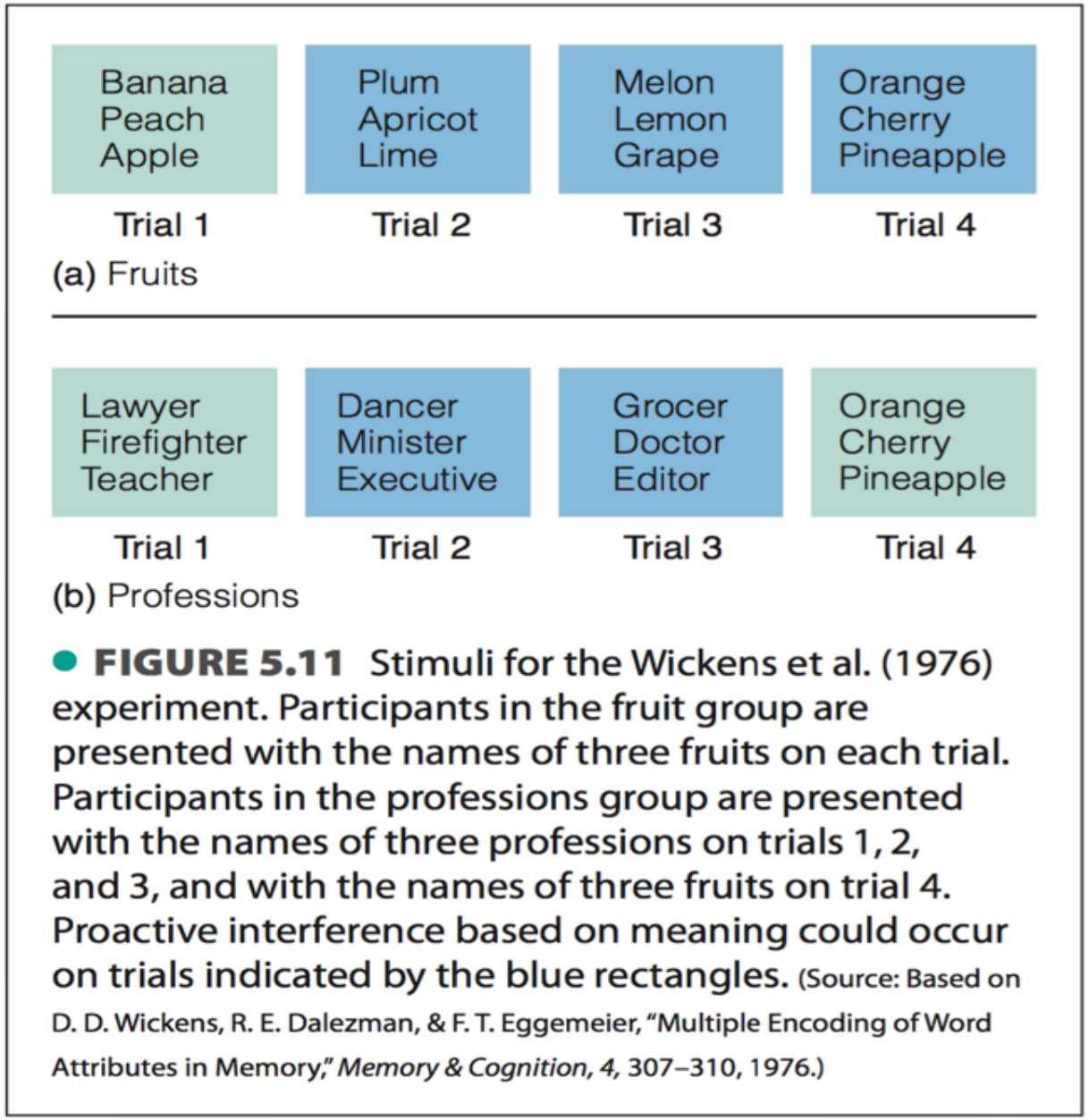


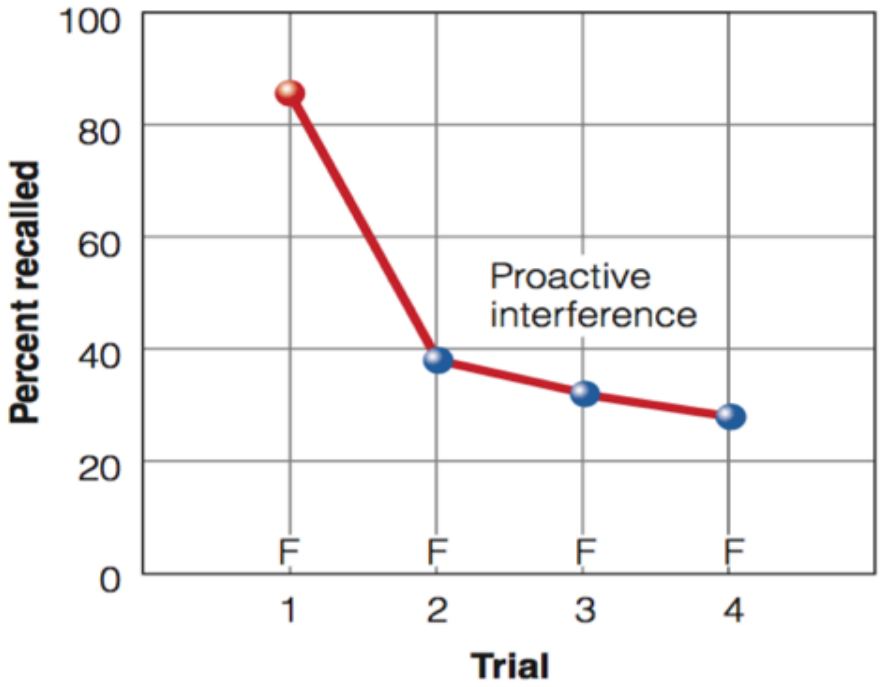
FIGURE 5.11 Stimuli for the Wickens et al. (1976) experiment. Participants in the fruit group are presented with the names of three fruits on each trial. Participants in the professions group are presented with the names of three professions on trials 1, 2, and 3, and with the names of three fruits on trial 4. Proactive interference based on meaning could occur on trials indicated by the blue rectangles. (Source: Based on D. D. Wickens, R. E. Dalezman, & F. T. Eggemeier, "Multiple Encoding of Word Attributes in Memory," *Memory & Cognition, 4,* 307–310, 1976.)

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (Fig. 5.11, p. 129).

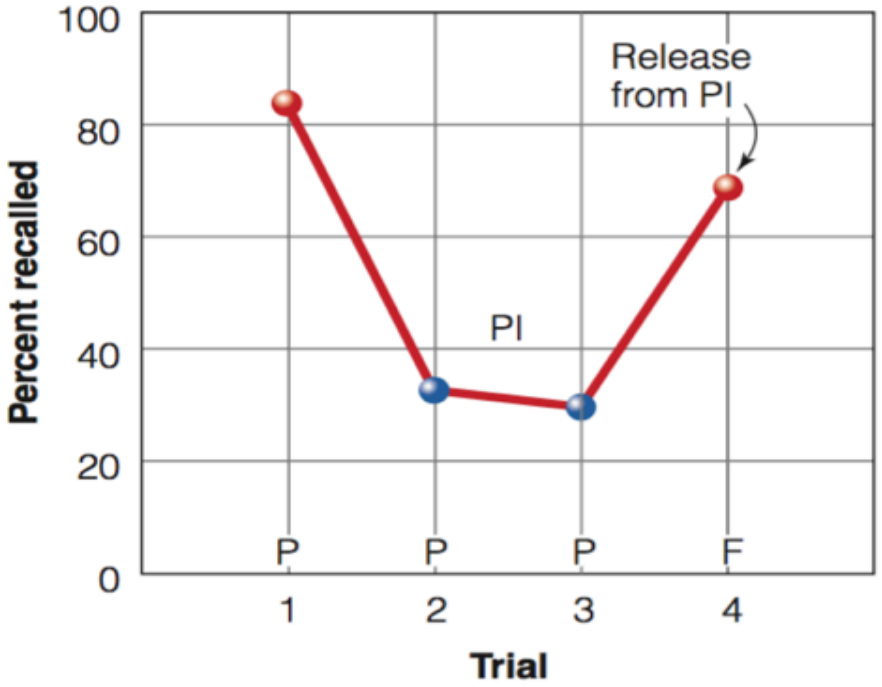
- Results:
  - For the fruits group, one the first trial the average percent recalled was 86%, but performance dropped on trials 2, 3,& 4 as additions names of fruits were presented.
  - The blue data points indicate the presence of proactive interference.
  - Evidence, that this interference can be attributed to the meanings the words is provided by the results of the professions drop.

- As with fruits, performance is high on trial 1 & then drops on trials 2 & 3.

- But on trial 4, the names of fruits are presented; & because these are from a different category, proactive interference is reduced & there is an increase in performance; this is called the **release from proactive interference.**



(a) Fruit group



(b) Professions group

● **FIGURE 5.12** Results of Wickens et al.'s (1976) proactive inhibition experiment. (a) Fruit group, showing reduced performance on trials 2, 3, and 4 caused at least partially by proactive interference (indicated by blue points). (b) Professions group, showing reduced performance on trials 2 and 3 but improved performance on trial 4. The increase in performance on trial 4 represents a release from proactive interference caused by the change of category from professions to fruits. (Source: Based on D. D. Wickens, R. E. Dalezman, & F. T. Eggemeier, "Multiple Encoding of Word Attributes in Memory," *Memory & Cognition, 4,* 307–310, 1976.)

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (Fig. 5.12, p. 130).

References

- Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed