Active Learning:
Sometimes something has to happen before something's going to happen

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Your attention please – Turn off your WMDs*

* Weapons of Mass Distraction

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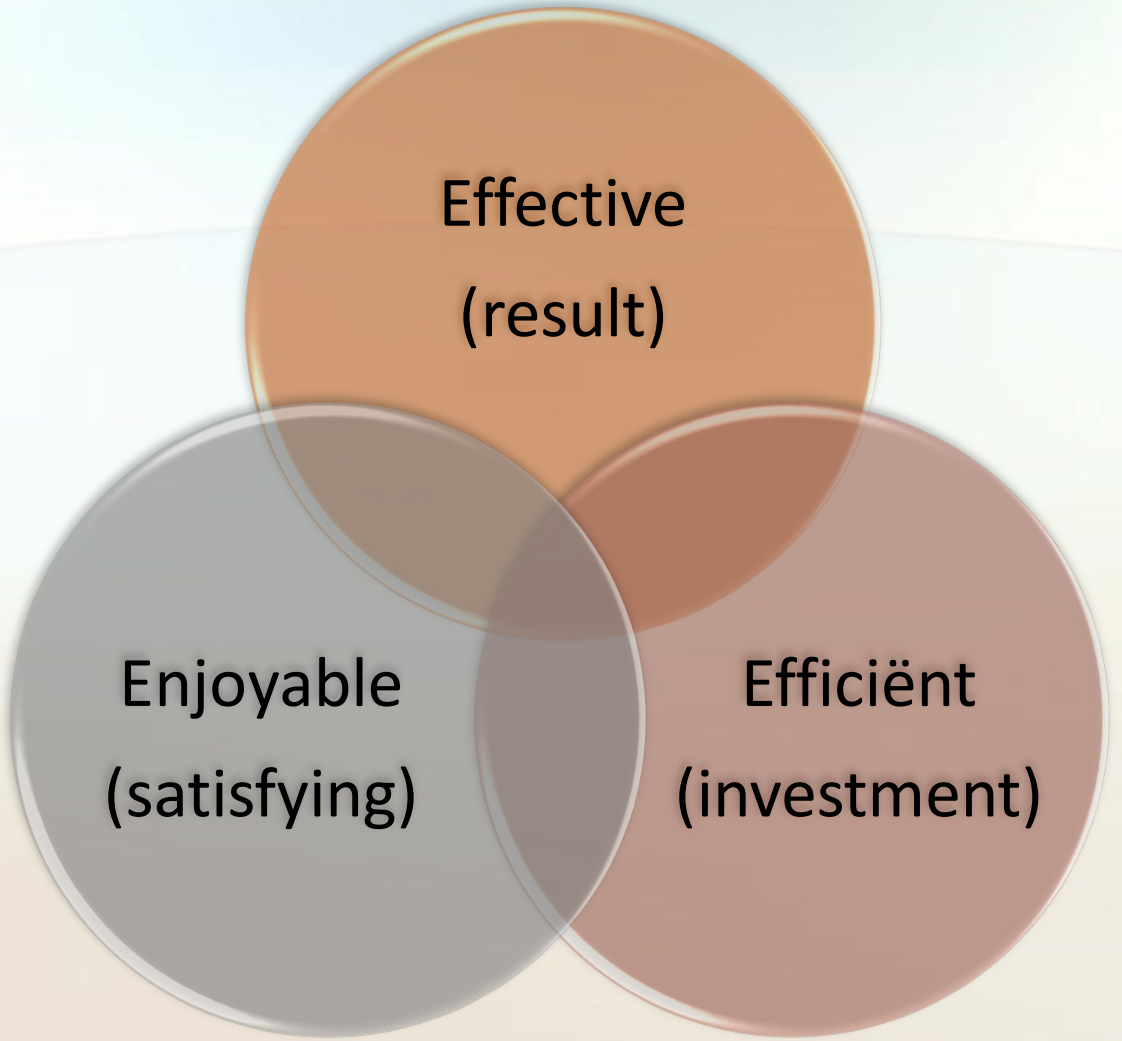
Sometimes something's got to happen before something is going to happen.
— Johan Cruijff —

What's Good Education?



Good learning depends on…

- how the student studies (**study strategy**)
- how the teacher teaches (**instructional strategy**)
- how a curriculum is set up (**school- and lessons**)
- nature of the student (**personality**)

Learning

- Change in **longterm memory**
- **Stable**
- Result of **cognitive processing** of information
- First **create** a network of neurons, then **(re)activate** that network

Poor Proxies for Learning

1. Students are busy: lots of work is done (especially written work)
2. Students are engaged, interested, motivated
3. Students are getting attention: feedback, explanations
4. Classroom is ordered, calm, under control
5. Curriculum has been 'covered' (ie presented to students in some form)
6. (At least some) students have supplied correct answers (whether or not they really understood them or could reproduce them independently)

Without an understanding of human cognitive architecture, instruction is blind

John Sweller at ACE Conference / researchED - Melbourne 2017

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The Science

- Information processing / Cognitive architecture (CLT)
- Desirable difficulties
- Generative learning strategies
- Testing and feedback

Learning

- Change in **longterm memory**
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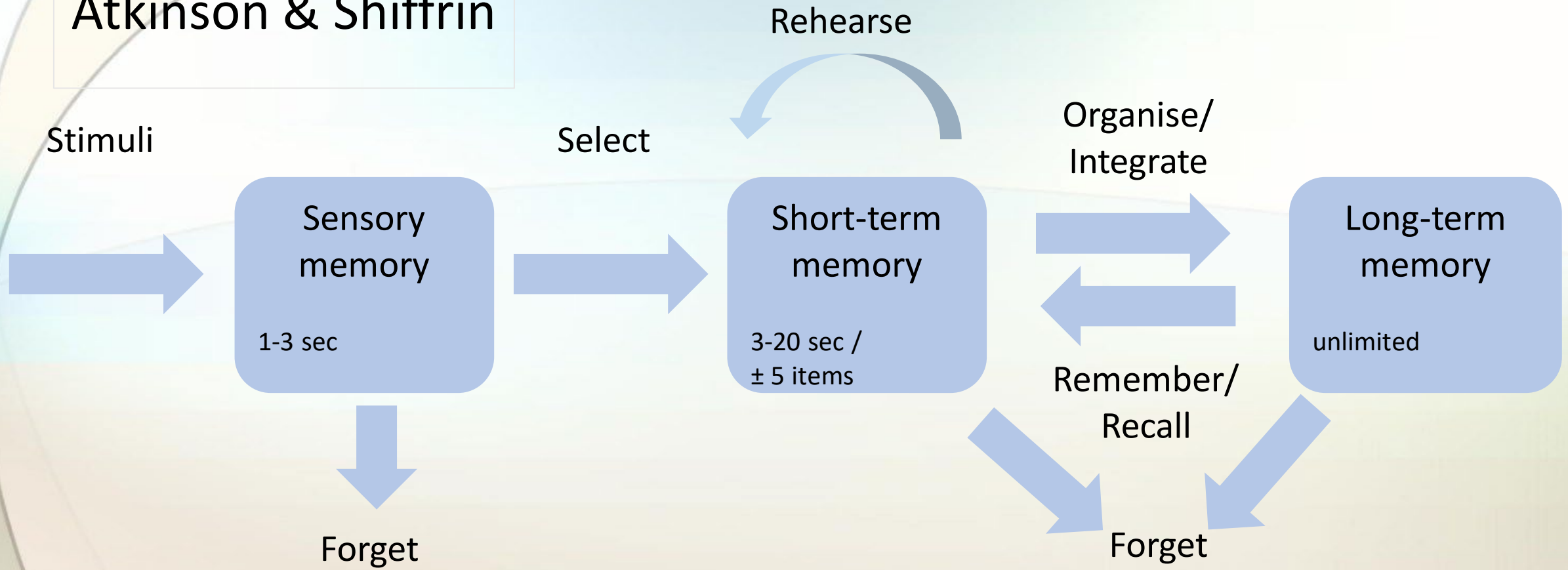
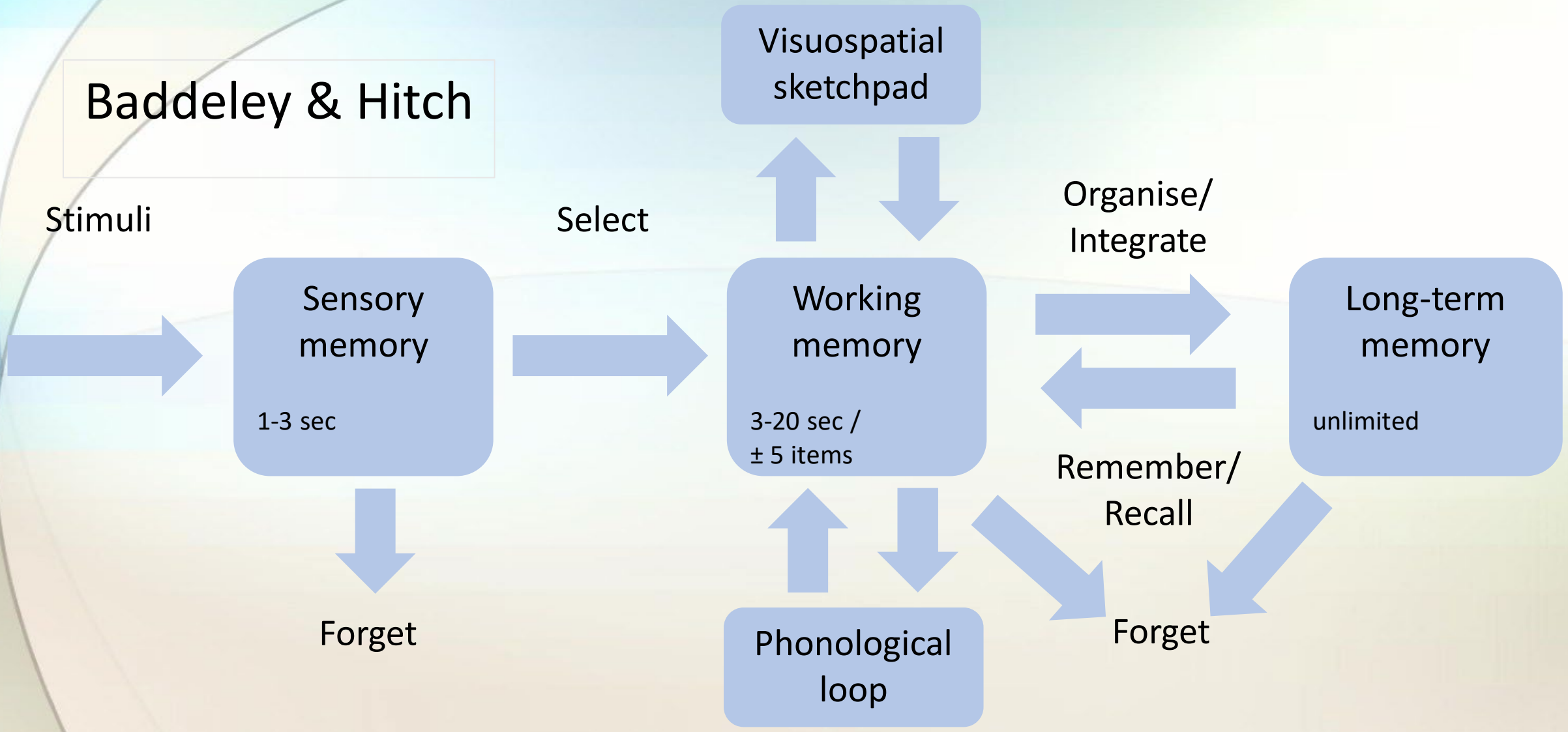
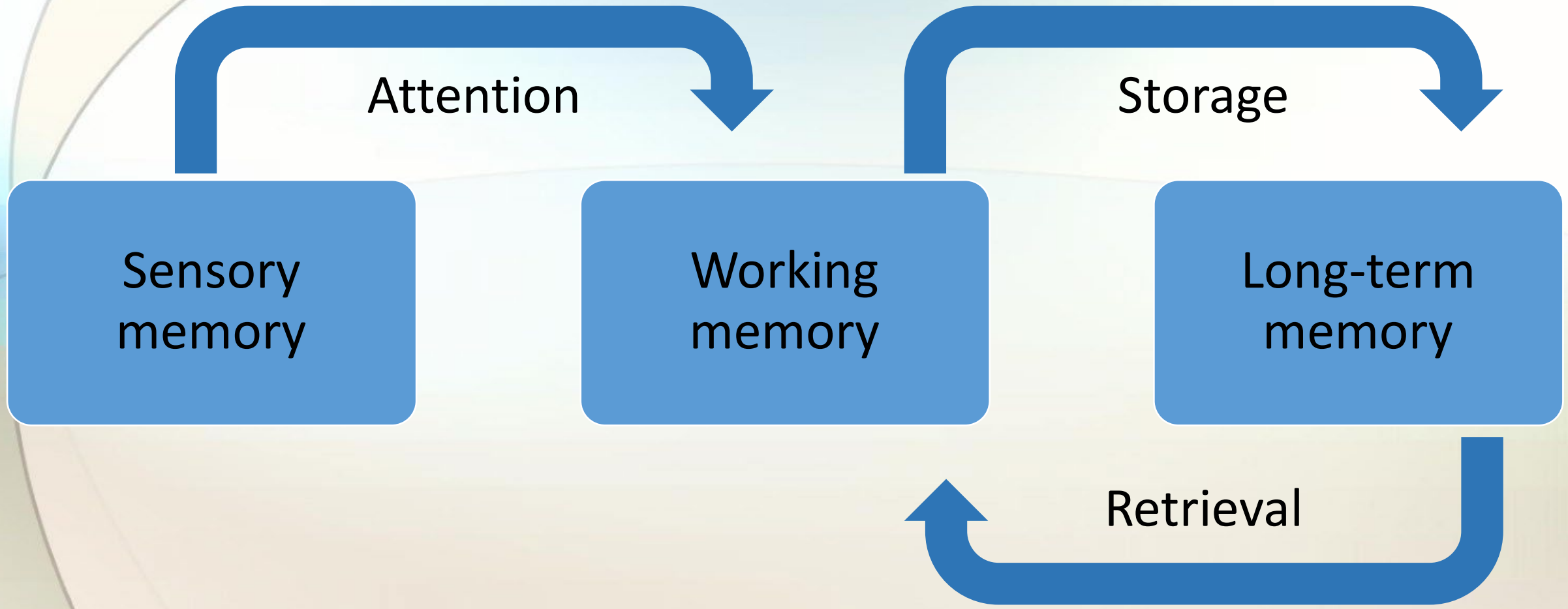
Atkinson & Shiffrin



Baddeley & Hitch




Attention
Storage
Sensory memory
Working memory
Long-term memory
Retrieval

Processing: Storage + Retrieval

- No processing = No learning
- Shallow processing = Shallow learning
- Deep processing = Deep learning
- More and more different processing = Better learning & retention

$$\sum_{1}^{n} Store \quad + \quad \sum_{1}^{n} Retrieve \quad = \quad \sum Learn/Retain$$

Learning as a Generative Activity

- Learning is **sense-making**

  "…the mind…is not a passive consumer of information, …it actively constructs its own interpretations of information and draws inferences on them." (Wittrock, 1989)

- Improve learning via:
  - instruction
  - learning/study strategies
- Cognitively active processing

Study strategy	
1. Elaborative interrogation	Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*, 4-58.
2. Self-explanation	
3. Summarisation	
4. Marking / Underlining	
5. Keyword mnemonic	
6. Imagery	
7. Rereading	
8. Practise testing	
9. Distributed practice	
10. Interleaved practice	

Study strategy	Description: The learner
1. Elaborative interrogation	…generates an explanation for why something is true
2. Self-explanation	…explains how the solution was reached / how the new information relates to what is already known
3. Summarisation	…summarises the text
4. Marking / Underlining	…marks or underlines the most important facets while reading the text
5. Keyword mnemonic	…thinks up keywords and mental imagery to associate verbal materials
6. Imagery	…tries to form mental images of text materials while reading or listening
7. Rereading	…reads the text a number of times
8. Practise testing	…tests themself or takes practice tests over to-be-learned material
9. Distributed practice	…implements a schedule of practice spreads out over time
10. Interleaved practice	...varies the practise order during study

Study strategy	Utility	Different types of learners	Different types of materials	Different types of tasks
1. Elaborative interrogation	moderate	good, more evidence needed	good	insufficient evidence
2. Self-explanation	moderate	good, more evidence needed	good	good, more evidence needed
3. Summarisation	low	sometimes yes, sometimes no	good, more evidence needed	sometimes yes, sometimes no
4. Marking / Underlining	low	sometimes yes, sometimes no	sometimes yes, sometimes no	poor
5. Keyword mnemonic	low	sometimes yes, sometimes no	sometimes yes, sometimes no	sometimes yes, sometimes no
6. Imagery	low	sometimes yes, sometimes no	sometimes yes, sometimes no	sometimes yes, sometimes no
7. Rereading	low	insufficient evidence	sometimes yes, sometimes no	sometimes yes, sometimes no
8. Practise testing	high	good, more evidence needed	good	good
9. Distributed practice	high	good, more evidence needed	good	good, more evidence needed
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Desirable Difficulties

Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe and A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp.185-205). MIT Press.

Bjork, R. A. (1994). Institutional impediments to effective training. In D. Druckman and R. A. Bjork (Eds.), *Learning, remembering, believing: Enhancing individual and team performance.* (pp.295-306). National Academy Press.

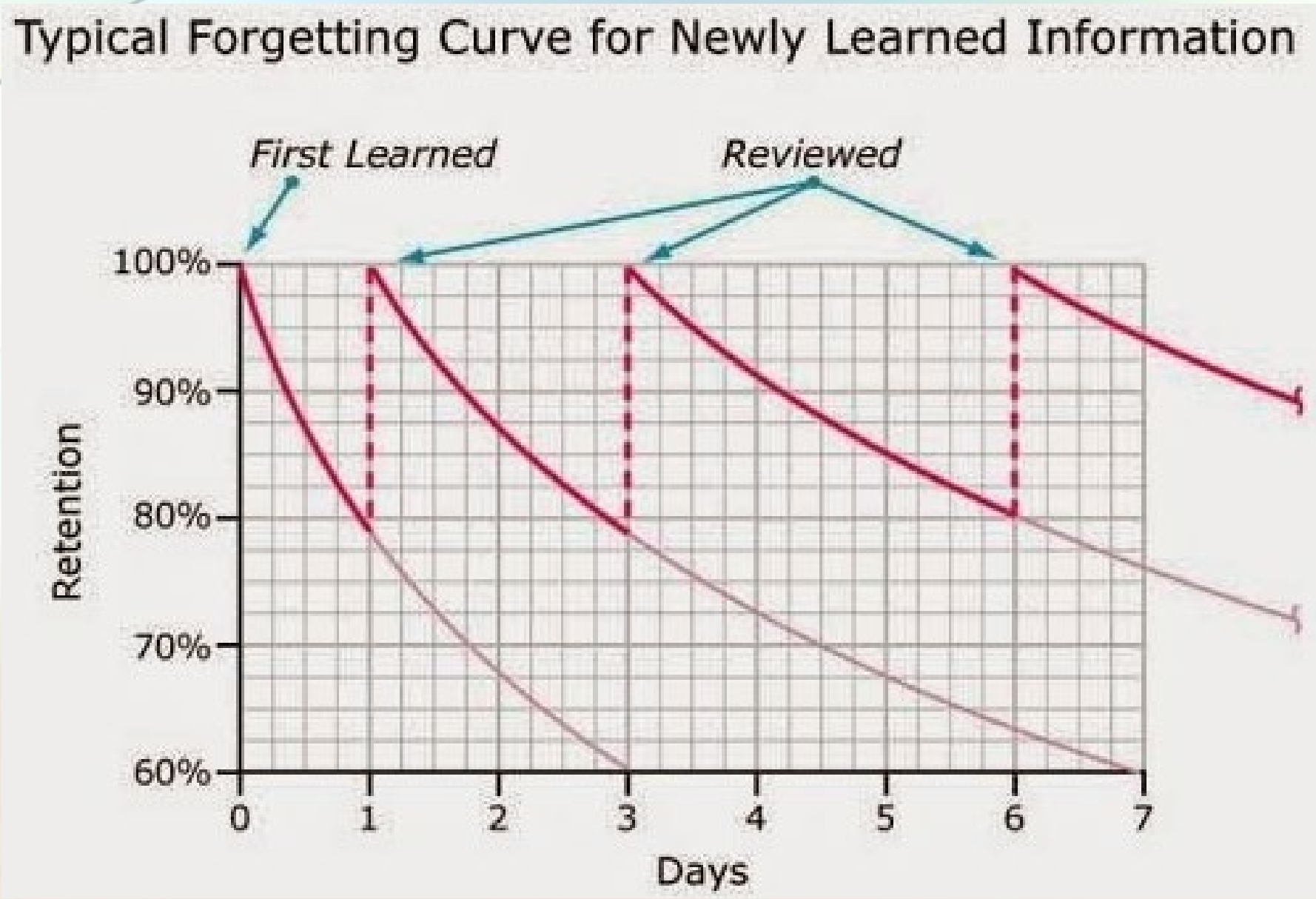
Desirable Difficulties

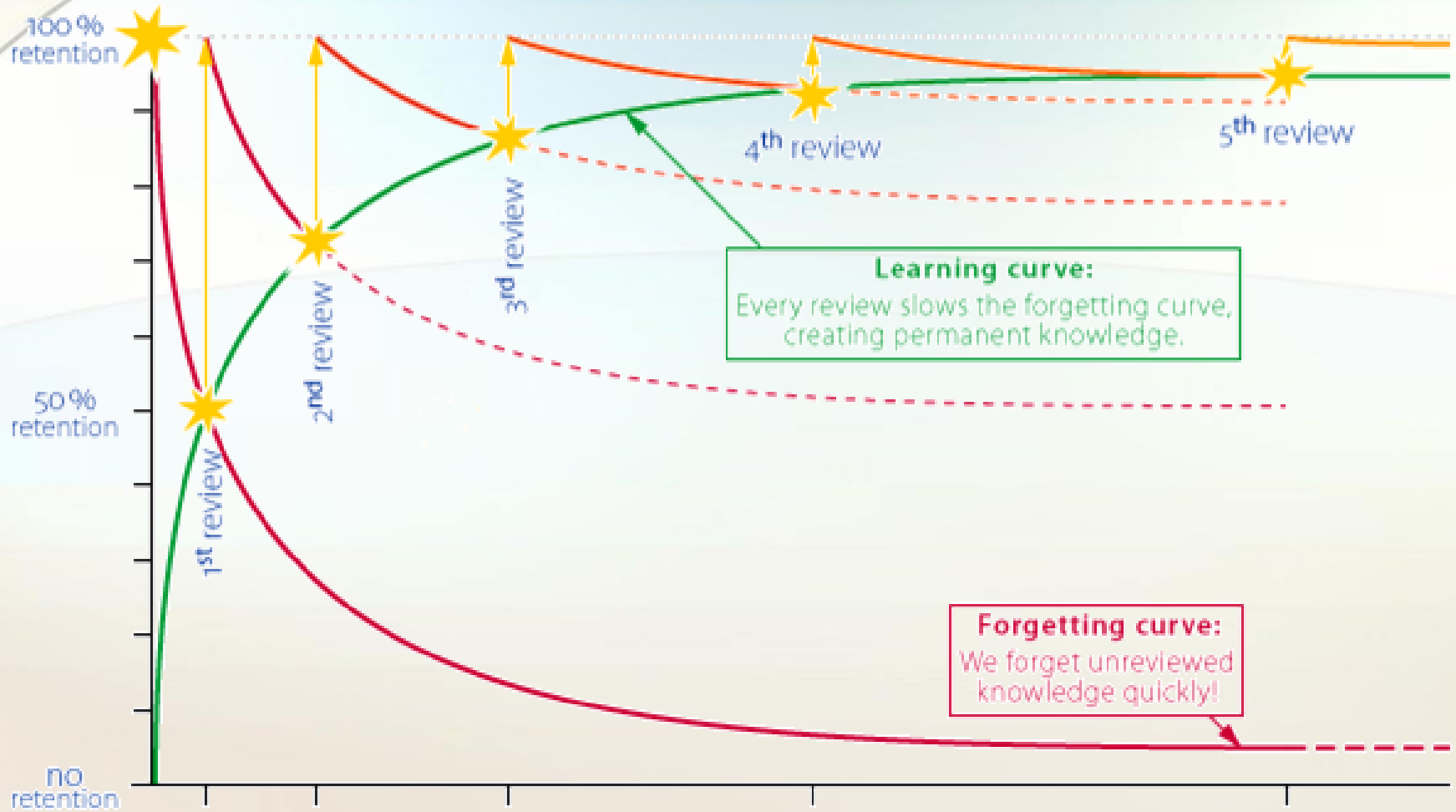
A learning task or study strategy that requires a considerable but desirable amount of effort, thereby improving long-term performance.

Desirable Difficulties

- Spaced practice – Hermann Ebbinghaus / Doug Rohrer

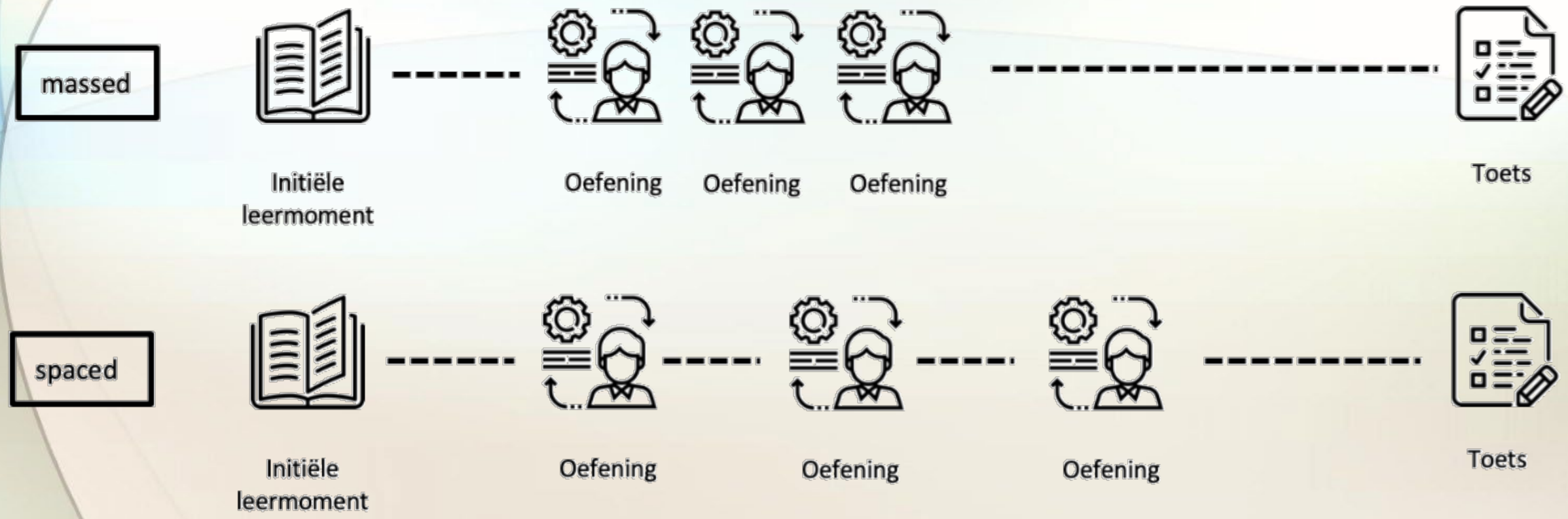
Spreading Learning Moments


Typical Forgetting Curve for Newly Learned Information
First Learned
Reviewed
100%
90%
80%
70%
60%
Retention
0
1
2
3
4
5
6
7
Days



https://thinkedu.net/blog/the-forgetting-curve-interleaving-vs-blocking/

Spreading Learning Moments



Vocabulary

TABLE 2

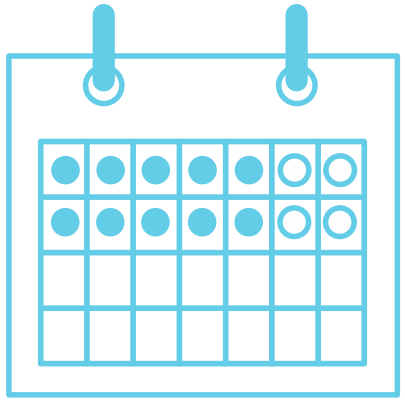
Mean percentage of correct recall of massed and spaced words (with *SD* in parentheses)

	Final test	
Learning condition	*After 1 week*	*After 5 weeks*
Massed	46.46% (25.85)	42.22% (23.07)
Spaced	55.96% (26.24)	49.49% (27.13)

HOW TO DO IT

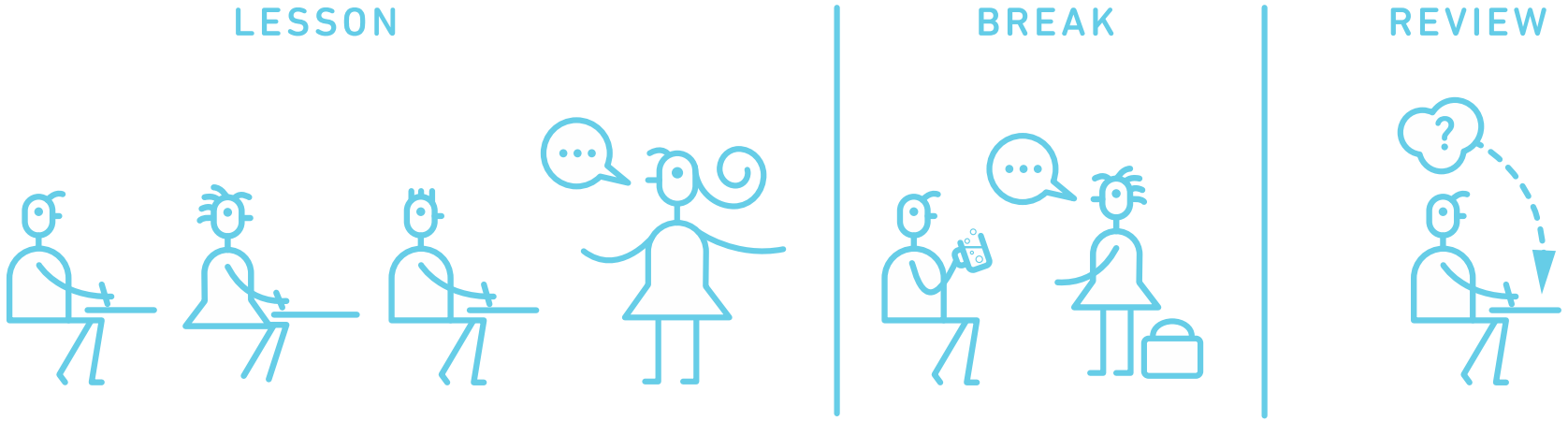
Start planning early for exams, and set aside a little bit of time every day. Five hours spread out over two weeks is better than the same five hours all at once.

M T W Th F Sa Su M T W Th F Sa Su



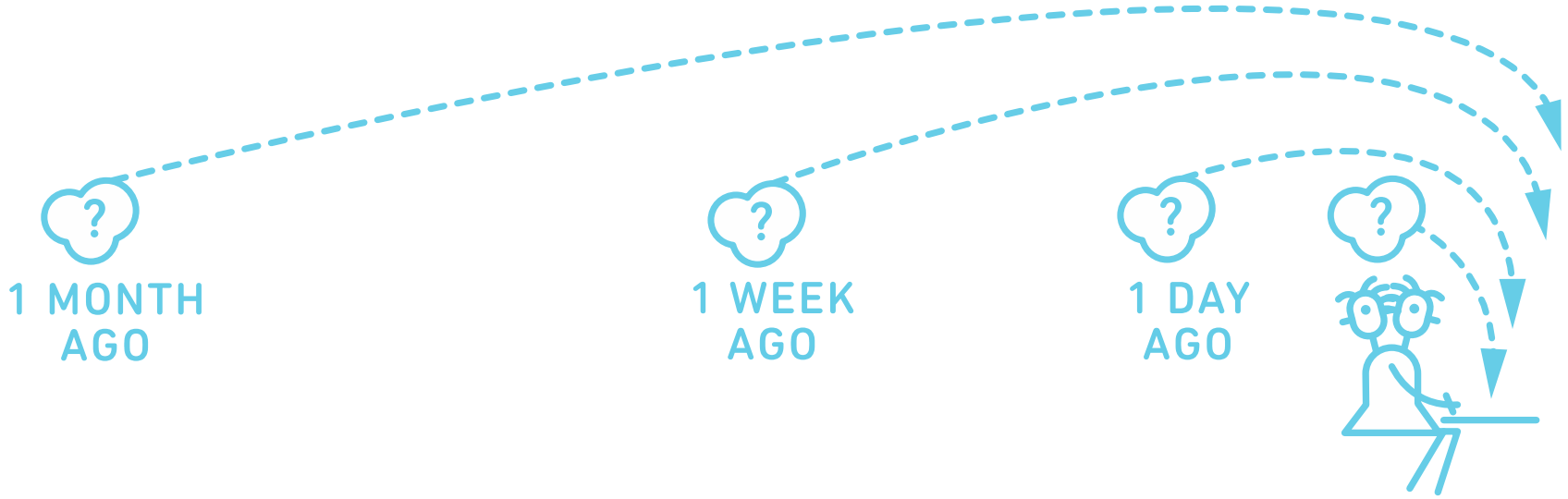
HOW TO DO IT

Review information from each class, but not immediately after class.



HOW TO DO IT

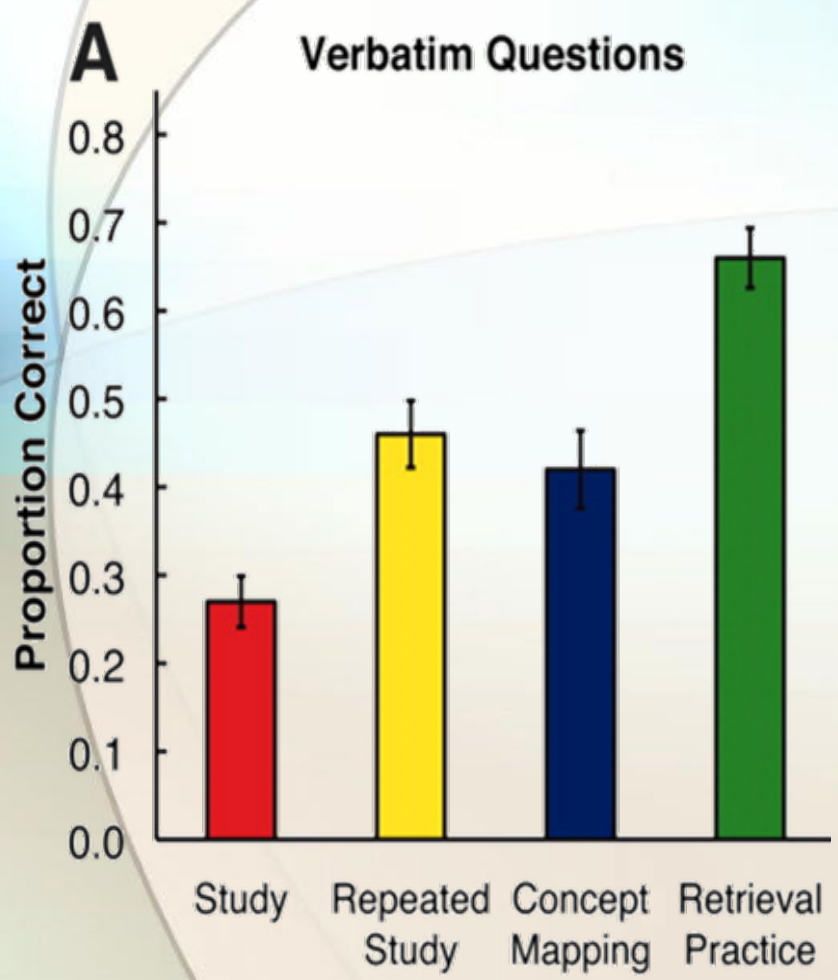
After you review information from the most recent class, make sure to go back and study important older information to keep it fresh.



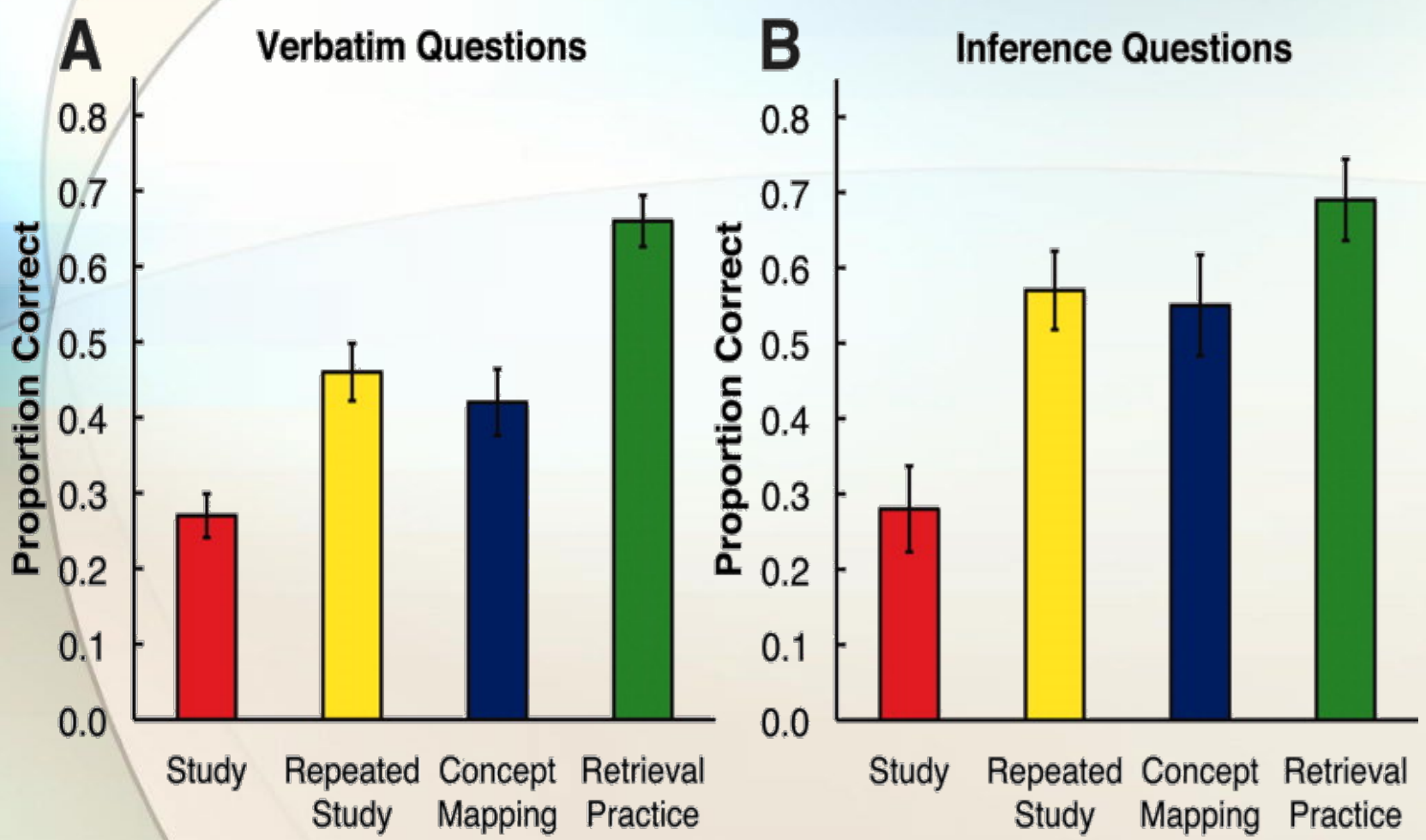
Desirable Difficulties

- Spaced practice – Hermann Ebbinghaus / Doug Rohrer
- Practice testing – Jeffrey Karpicke

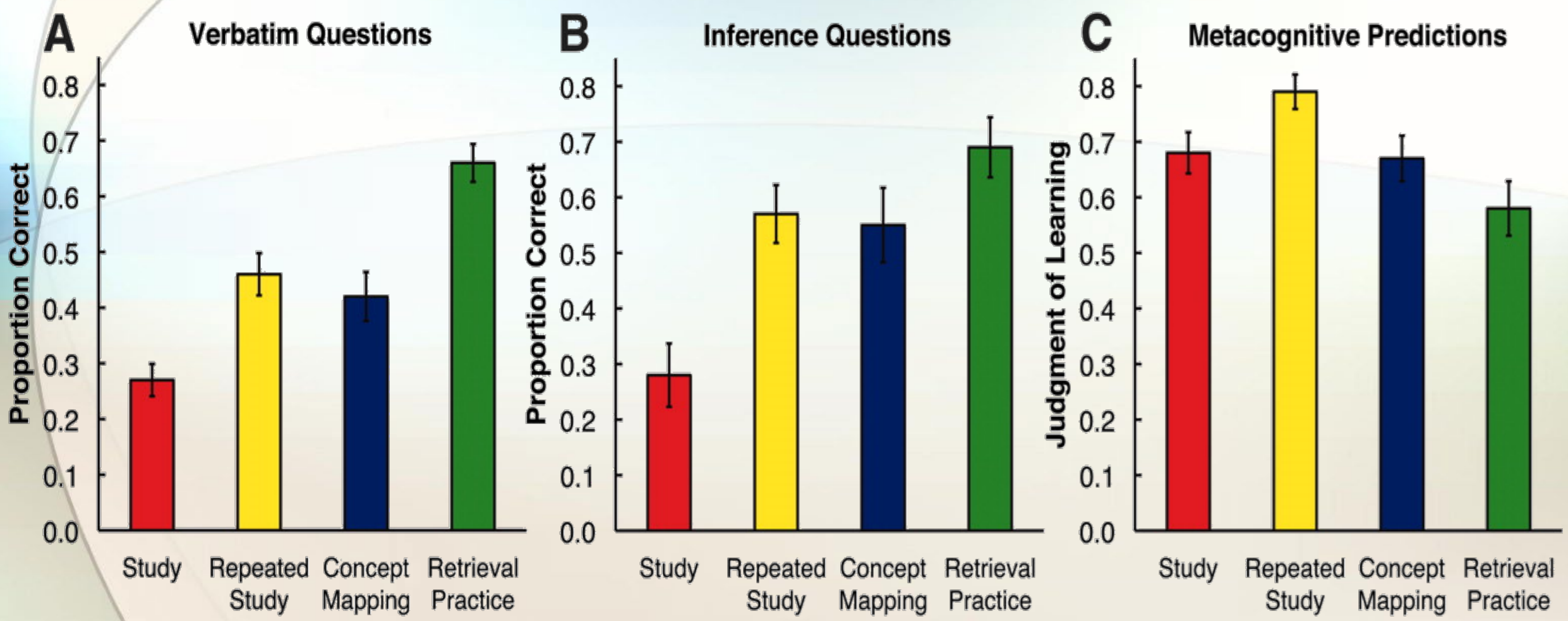
Practice Testing

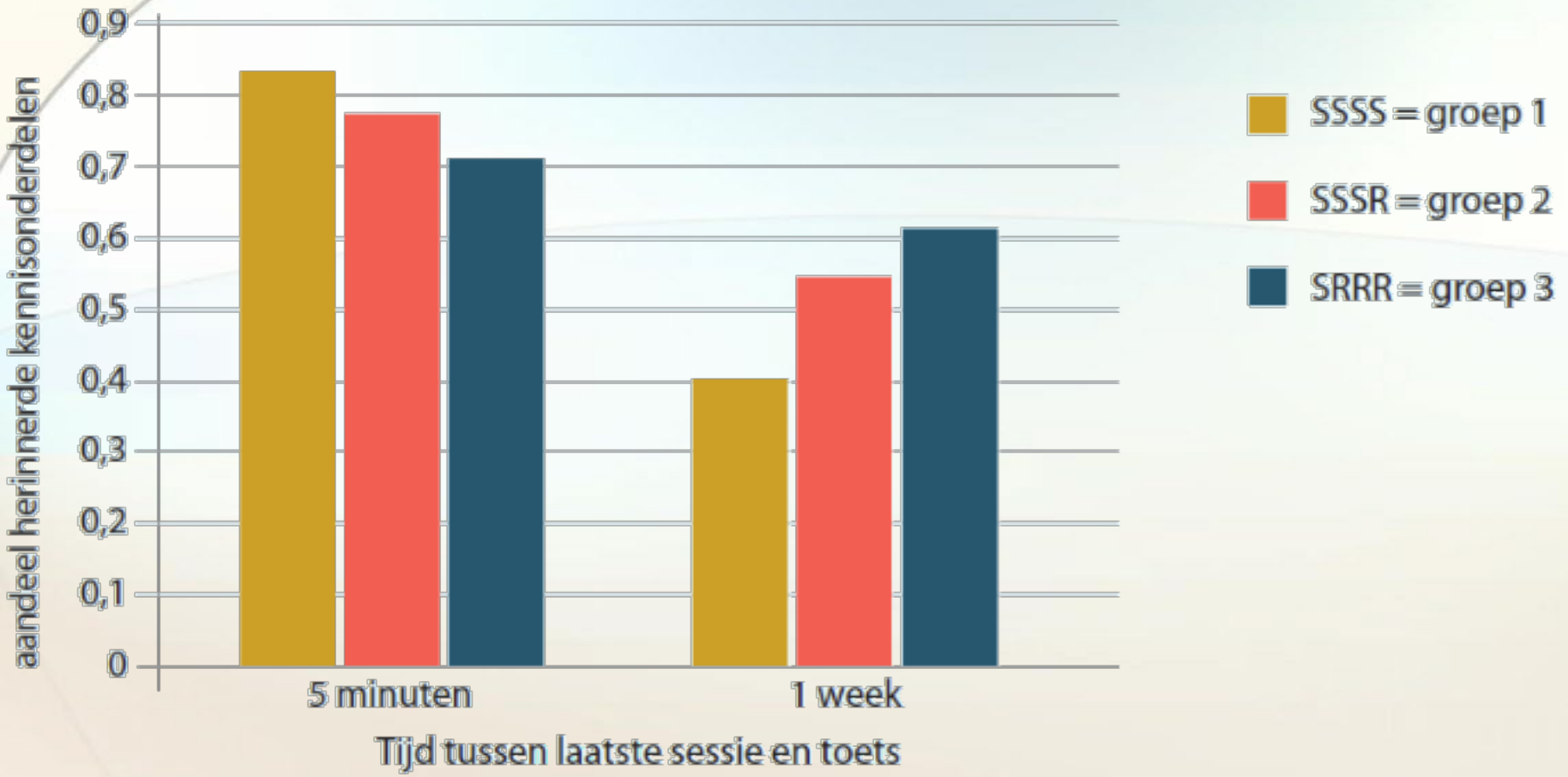


Practice Testing

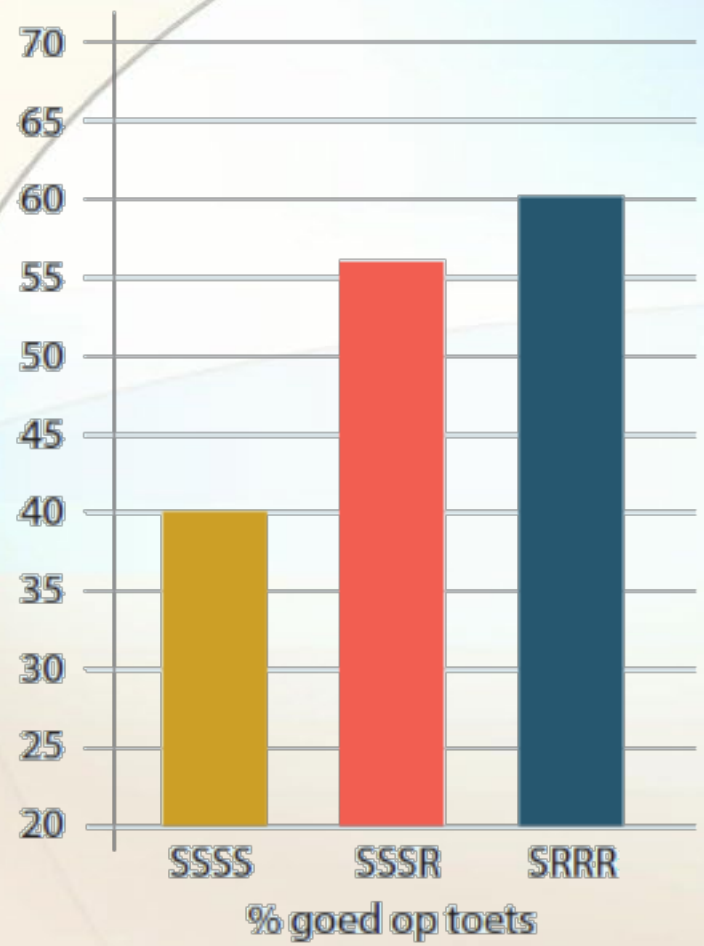


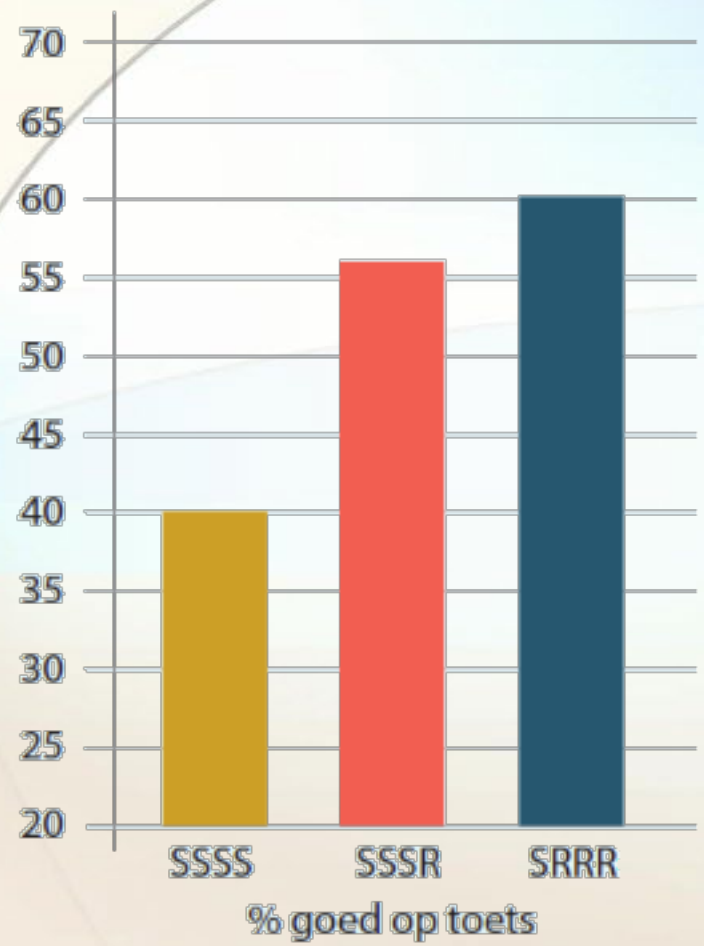
Practice Testing





Roediger & Karpicke (2006)


70
65
60
55
50
45
40
35
30
25
20
SSSS
SSSR
SRRR
% goed op toets


70
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SSSS
SSSR
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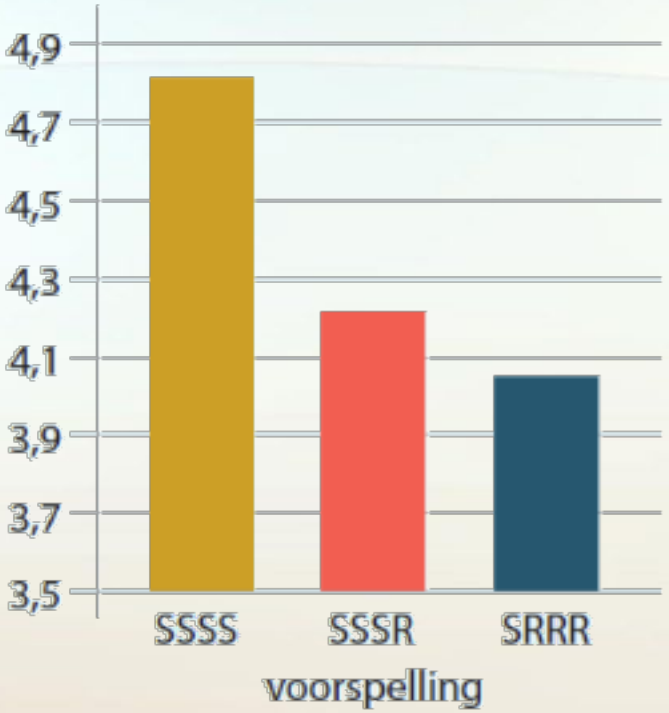
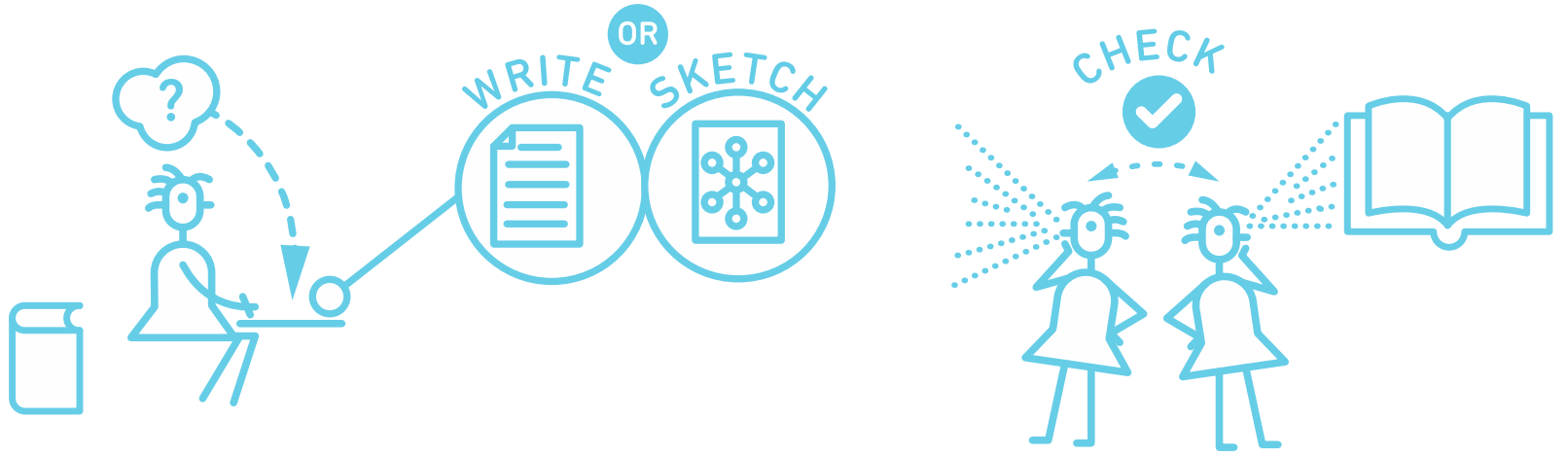
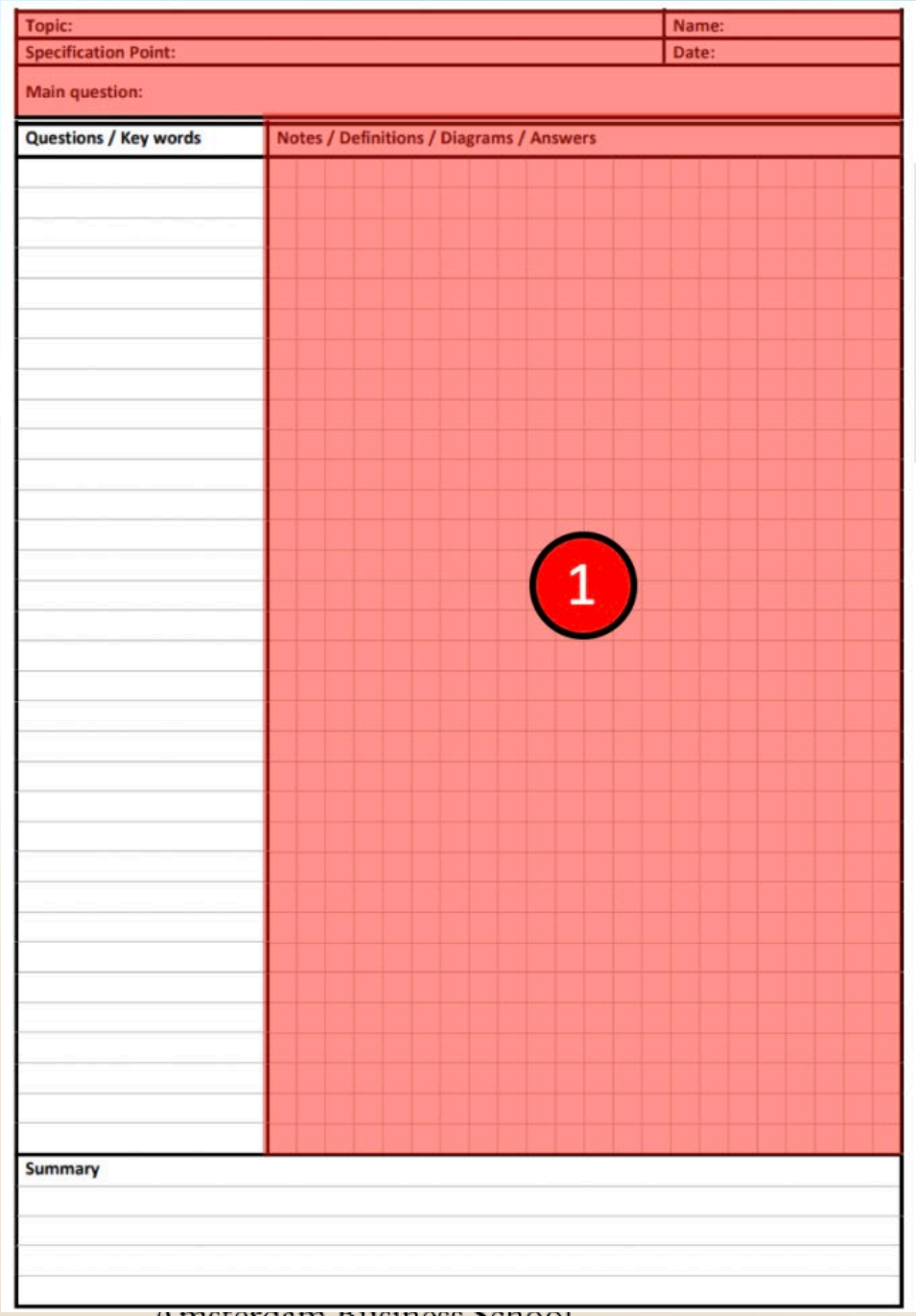

4,9
4,7
4,5
4,3
4,1
3,9
3,7
3,5
SSSS
SSSR
SRRR
voorspelling

HOW TO DO IT

Put away your class materials, and write or sketch everything you know. Be as thorough as possible. Then, check your class materials for accuracy and important points you missed.

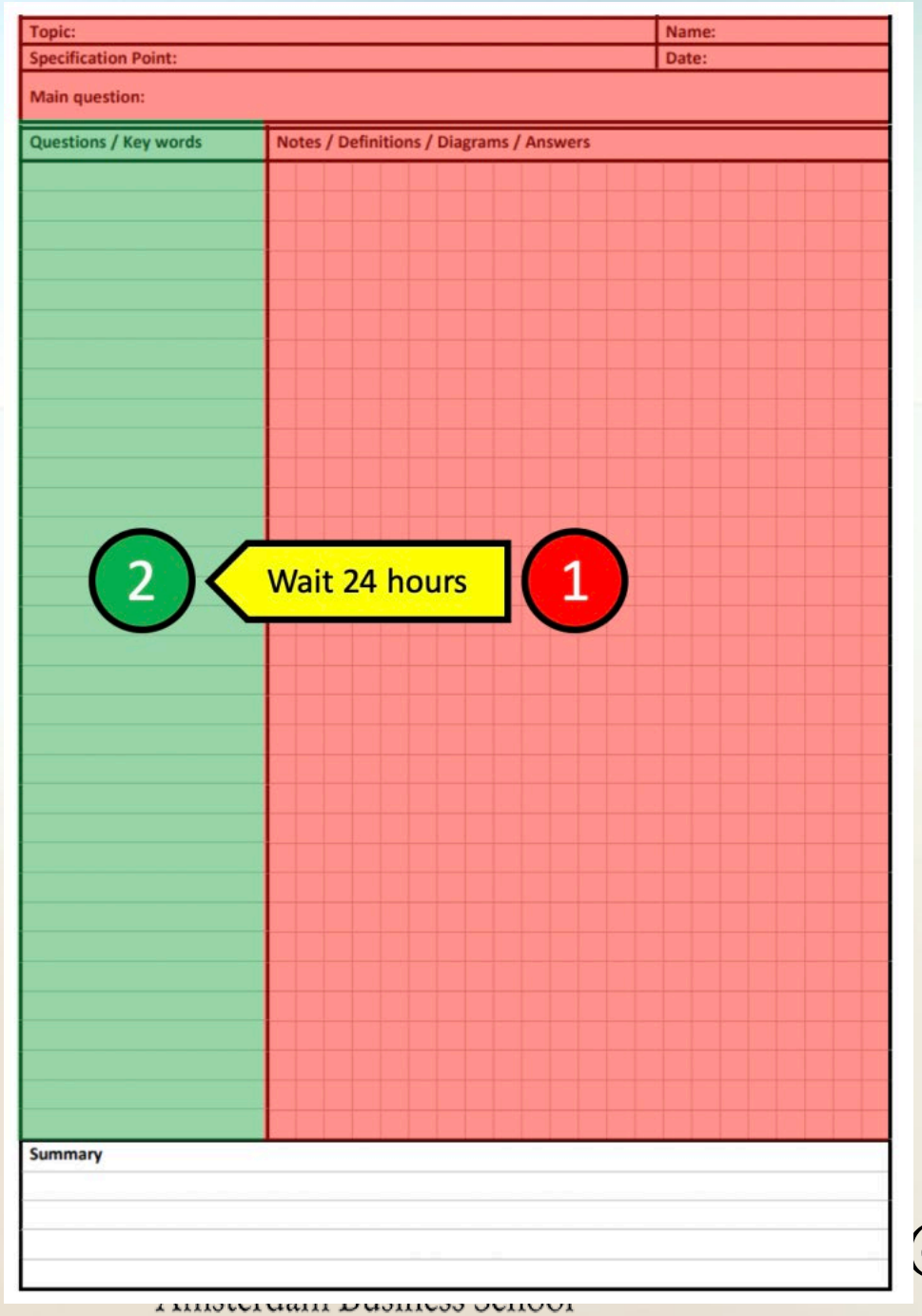




https://emc2andallthat.wordpress.com/

Cornell versus Ebbinghaus

Gethyn Jones



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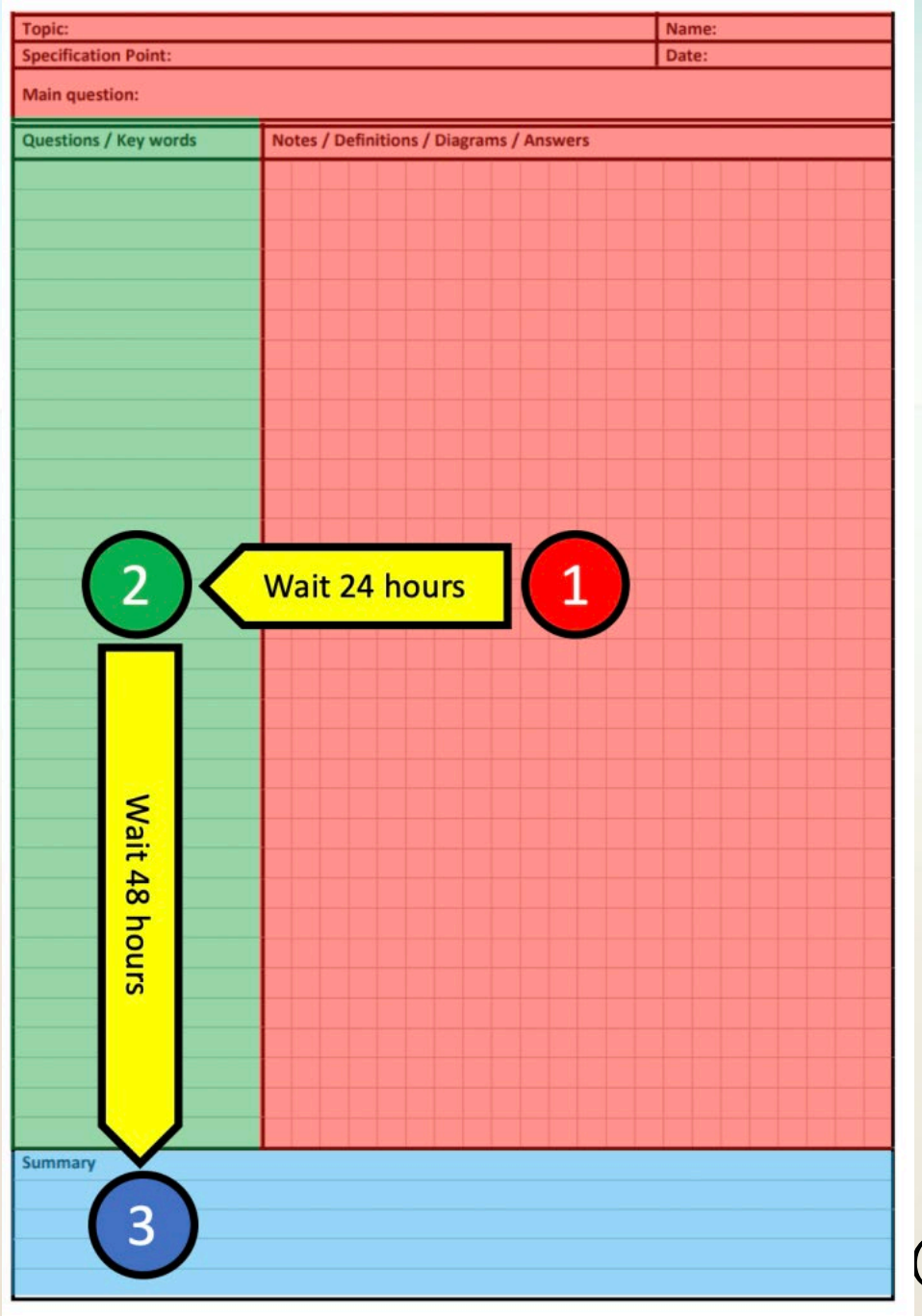

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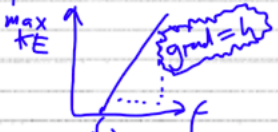
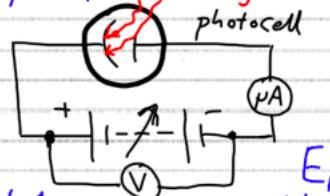
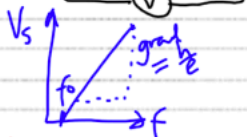
Topic: PHOTOELECTRIC EFFECT	Name:
Specification Point: 3.2.2.1	Date:
Main question: What is the photoelectric effect and how does Einstein's photoelectric equation define it.	

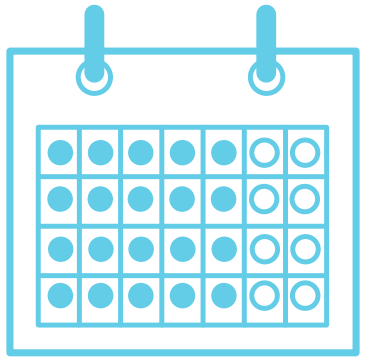
Questions / Key words	Notes / Definitions / Diagrams / Answers
What are photoelectrons?	Electrons (called photoelectrons) are emitted from the surface of a metal when bright light is incident on the metal.
Relationship between intensity and no. of photoelectrons	The higher the *intensity* of the light then the greater the number of photoelectrons emitted. * $I = P/A \Rightarrow W\,m^{-2}$
How frequency affects max KE. THRESHOLD FREQUENCY	The frequency of the incident light affects the maximum KE of the photoelectrons. There is a threshold frequency below which no photoelectrons are emitted.
Graph of $E_{K(max)}$ against frequency.	 f_0 is the threshold frequency
Work function and threshold frequency.	$E_{K,max} = hf - \phi$ (J s) Planck's constant $h = 6.63 \times 10^{-34}$ Work function. Einstein's Photoelectric Eqn. NOTE: $\phi = hf_0$ Work function is the minimum energy needed for a photoelectron to escape the surface.
Evidence that e-m radiation consists of particles.	NOTE: 1 photon interacts with 1 electron so $\phi = hf_0$ incident light $\lambda = \frac{c}{f}$
Photocell circuit and stopping potential V_s.	 The stopping potential is the PD which just stops the photoelectrons so the μA read zero. $E_{K,max} = V_s \times e$
Graph of stopping potential against frequency.	 $eV_s = hf - \phi$ $V_s = \frac{hf}{e} - \frac{\phi}{e}$ $y = mx + c$

Summary

1. The PE effect is when photoelectrons are emitted from the surface of a metal when light with a frequency greater than the threshold frequency is incident upon it.
2. $E_{K(max)}$ is equal to the energy of the photon (hf) minus the work function (ϕ). It does not predict the number of photoelectrons emitted: that depends on the intensity of the light.

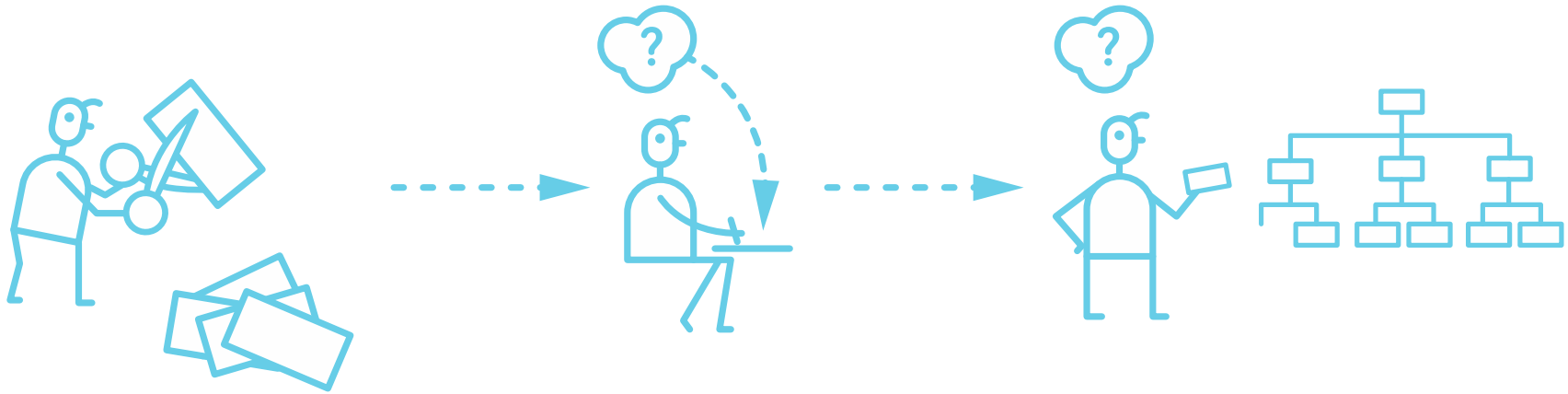
HOW TO DO IT

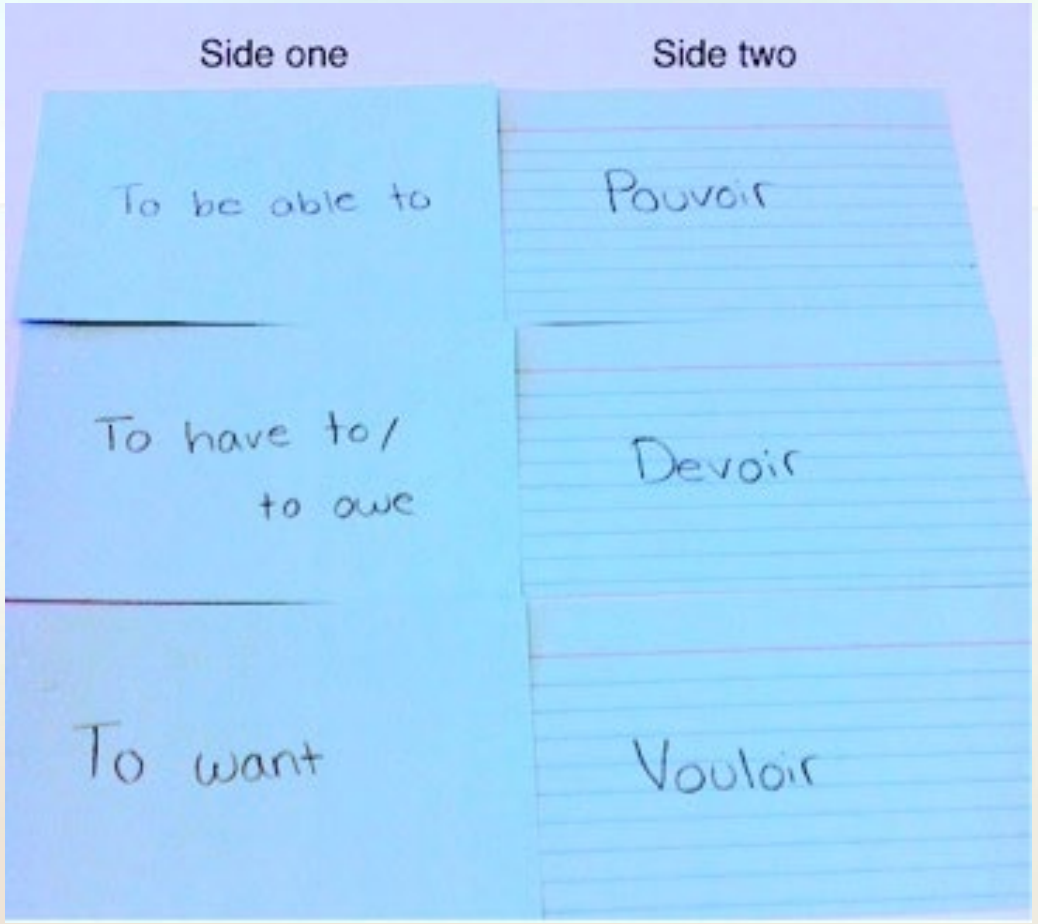
Take as many practice tests as you can get your hands on. If you don't have ready-made tests, try making your own and trading with a friend who has done the same.

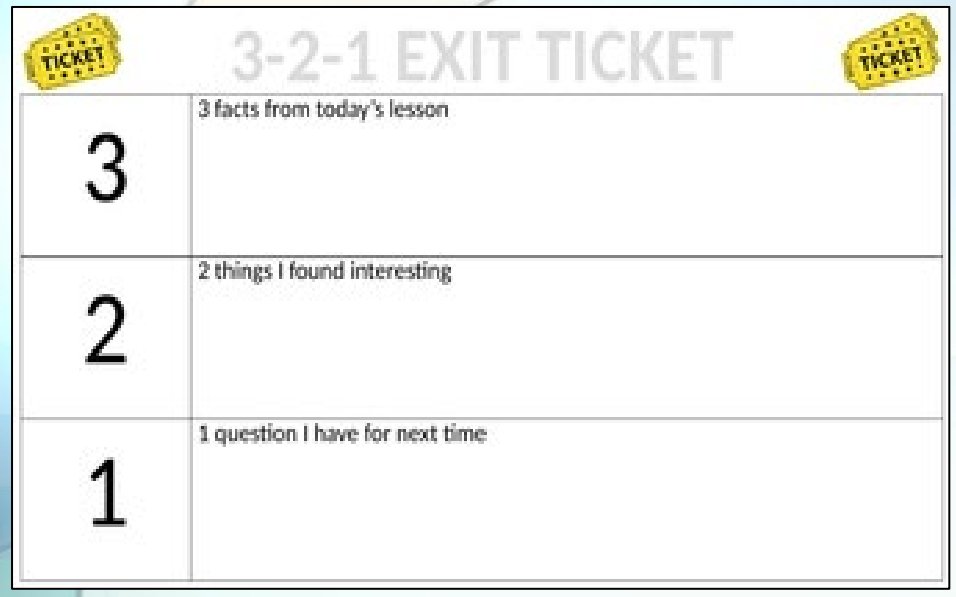


HOW TO DO IT

You can also make flashcards. Just make sure you practice recalling the information on them, and go beyond definitions by thinking of links between ideas.

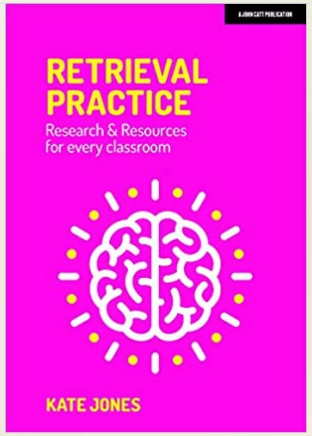



Side one
Side two
To be able to
Pouvoir
To have to/
to owe
Devoir
To want
Vouloir



Who was Head of the Cheka in 1917?	Explain the term bourgeoisie.	Who was Anatoly Lunacharsky?	List four different enemies of the Cheka.
Describe Khrushchev's attitude towards religion.	Explain the term 'Proletkult'.	List three aims of the NEP.	What was the October 1917 Decree on Land?
Explain the term 'show trial'.	Who was Patriarch Tikhon?	What were the aims of agitprop?	Describe one strength and one weakness of War Communism.
Last lesson (1)	Last week (2)	Two weeks ago (3)	Further back! (4)

Kate Jones
https://lovetoteach87.com/



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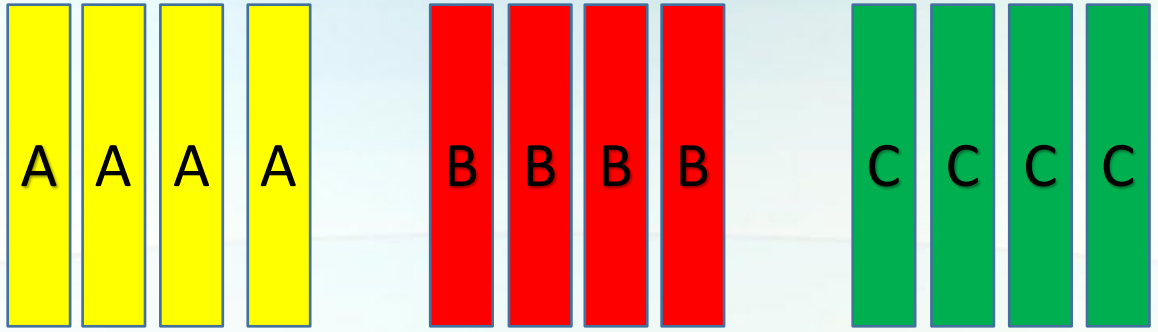
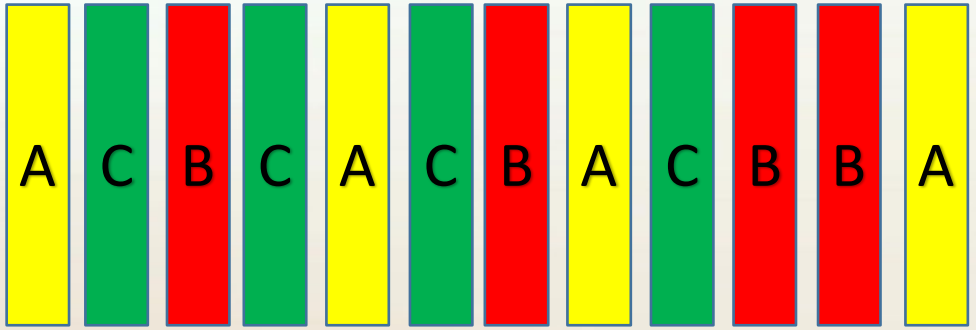
Desirable Difficulties

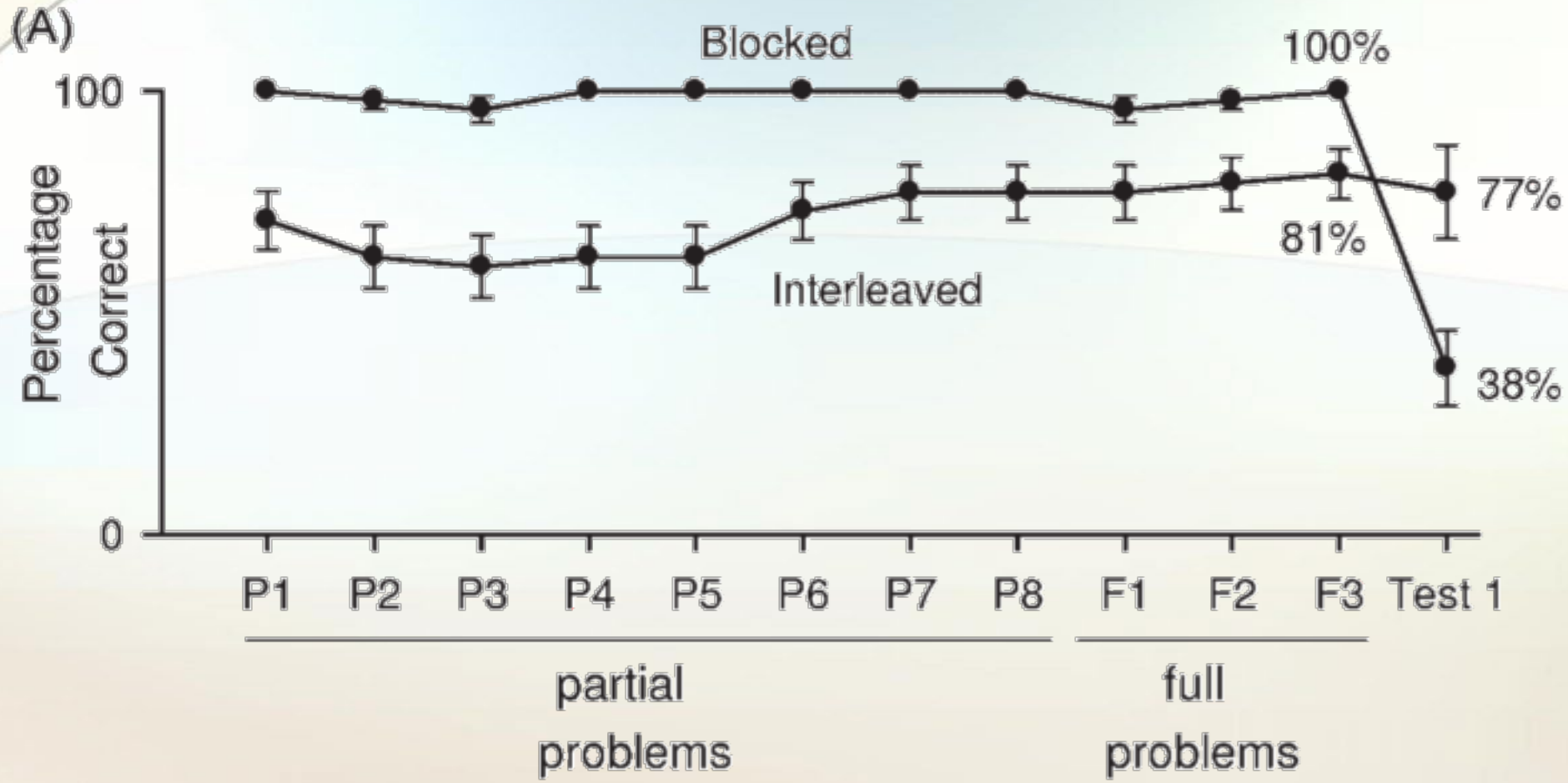
- Spaced practice – Hermann Ebbinghaus / Doug Rohrer
- Practice testing – Jeffrey Karpicke
- Interleaving – Henry Roediger / Jeroen van Merriënboer & Paul Kirschner

Massed Practice



Interleaved Practice





(Taylor & Rohrer, 2010)

WHY INTERLEAVING WORKS

by **@Inner_Drive**
innerdrive.co.uk

What it is:

Blocking

Blocking involves doing topic 1, then topic 2, then topic 3.

Interleaving

Interleaving involves mixing up topics within a subject.

Why it works:

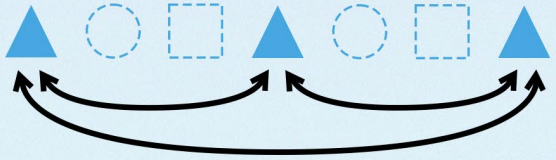
1. Discrimination learning: Spotting **differences between similar things**

When students think about differences, we prompt them to think harder. Contrasting information is more likely to stick in our mind.

2. Involves remembering **similarities between different things**

By highlighting similarities between different things, we provide more "anchor points" for students to hook new information onto.

3. Involves the **benefits of spacing**



Each time the information is revisited, it helps ingrain and cement it into our long-term memory.

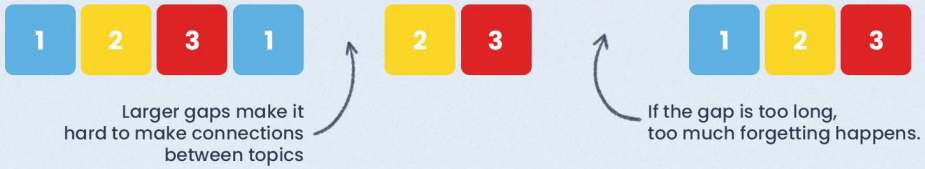
The Do's and Don'ts of Interleaving

by @Inner_Drive | **innerdrive.co.uk**

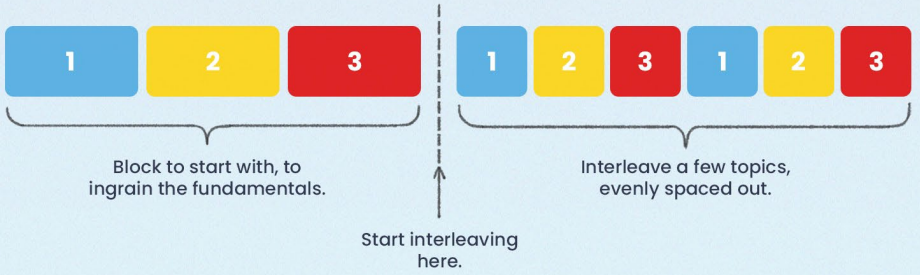
Don't: Interleave subjects instead of topics

Don't: Interleave too many topics

Don't: Leave too long between interleaving sessions



Do: Master the basics first, choose a few related topics, and leave consistent gaps between sessions

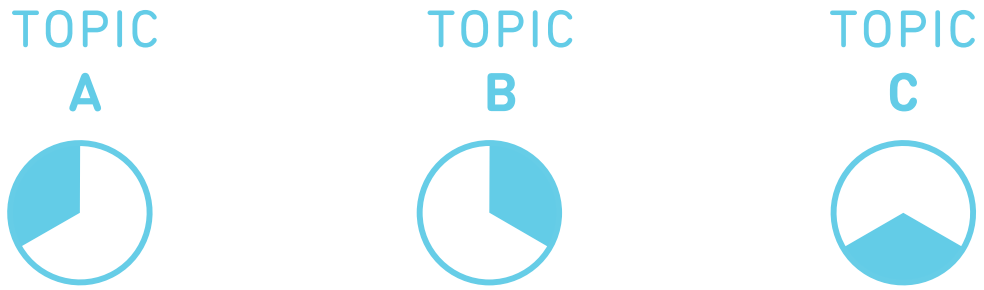


kirschner^ED

@P_A_Kirschner

HOW TO DO IT

Switch between ideas during a study session. Don't study one idea for too long.



HOW TO DO IT

Go back over the ideas again in different orders to strengthen your understanding.

TOPICS
A B C

STUDY SESSION 1

TOPICS
C B A

STUDY SESSION 2

TOPICS
A C B

STUDY SESSION 3

Generative Learning Strategies

Fiorella, L., & Mayer, R. E. (2015). *Learning as a generative activity: Eight learning strategies that promote understanding*. Cambridge University Press.

Brod, G. (2021) Generative learning: Which strategies for what age? *Educational Psychology Review, 33*, 1295–1318.

Generative Learning Strategies

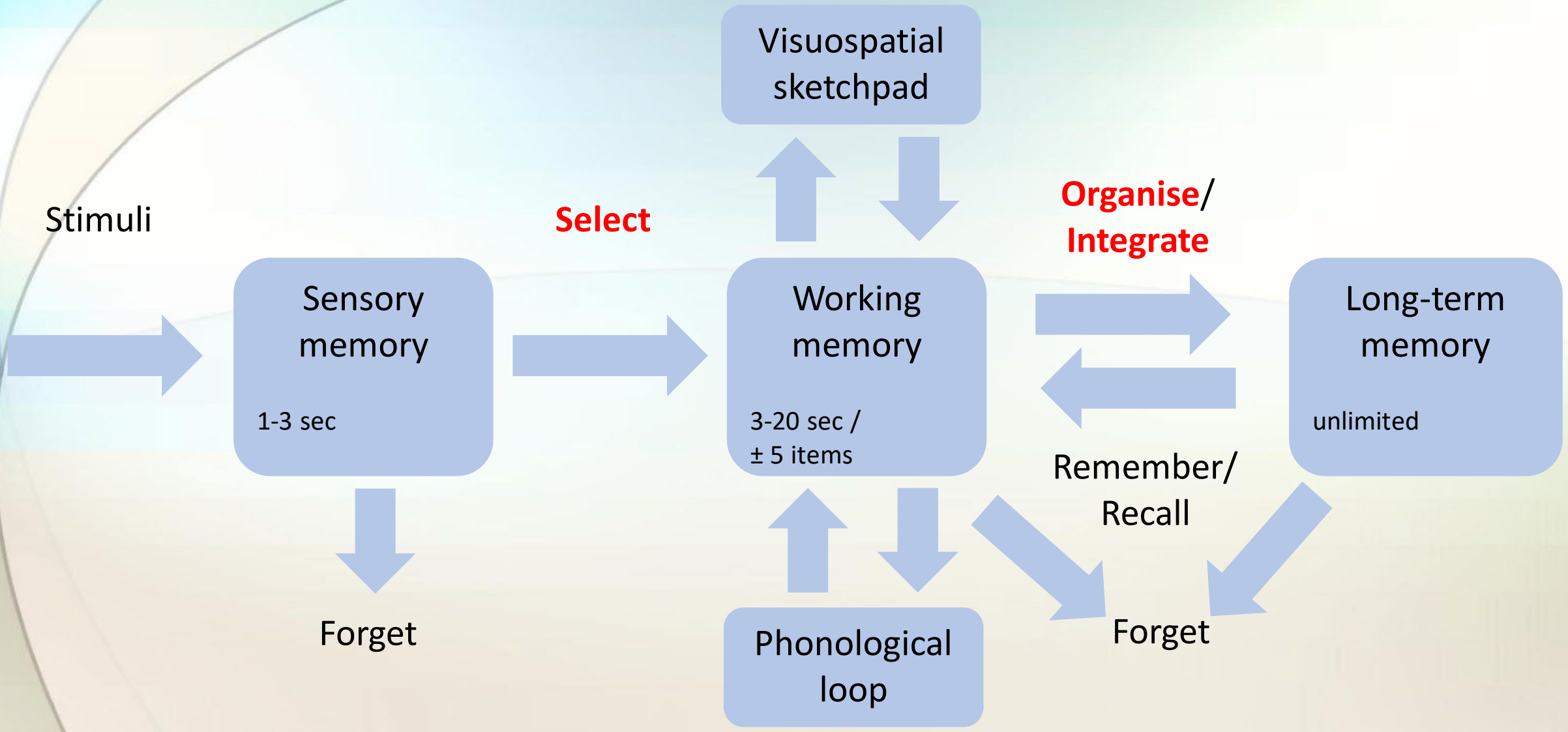
Asks students to actively **reorganise** the learning material and **integrate** it with their prior knowledge.

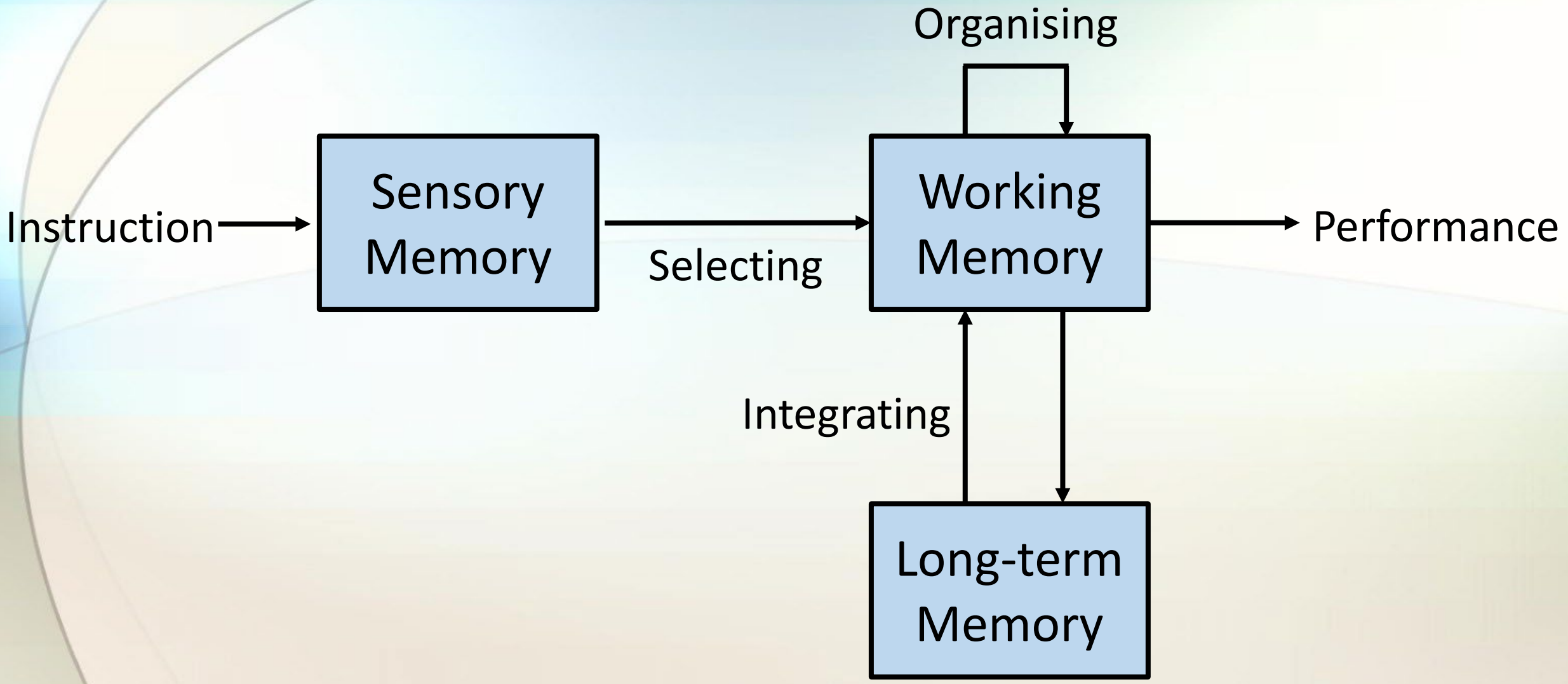
Prompts students to **produce** something meaningful **beyond** the information provided.

Not just about being **engaged** with the learning material.

Generative Learning Strategies

Generative learning strategies require students to make sense of new information by **selecting** important information, **reorganising** and **integrating** the newly acquired information with what is already known.


Visuospatial sketchpad
Stimuli
Select
Organise/
Integrate
Sensory memory
1-3 sec
Working memory
3-20 sec /
± 5 items
Long-term memory
unlimited
Remember/
Recall
Forget
Phonological loop
Forget


Organising
Instruction
Sensory Memory
Selecting
Working Memory
Performance
Integrating
Long-term Memory

Fiorella & Mayer

- Summarise – main points (short) in own words
- Map – written/spoken text in a spatial representation
- Draw – visual representation of the contents
- Imagine – mental image of the contents
- Self-test - retrieval-based learning
- Self-explain – explain the content to yourself
- Teach – explain to a (fictitious) other
- Enact – task-relevant movements

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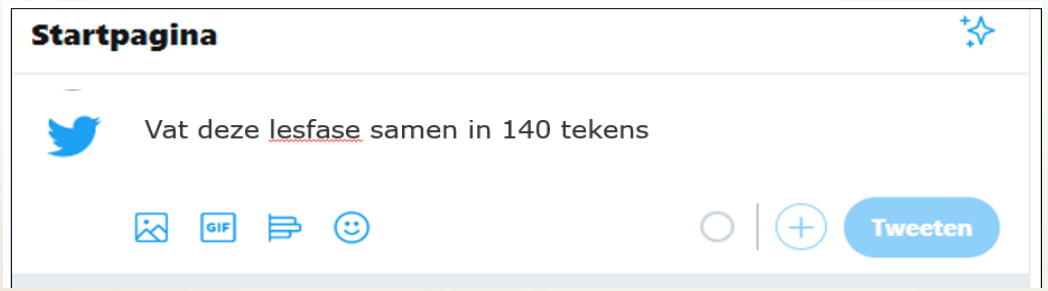
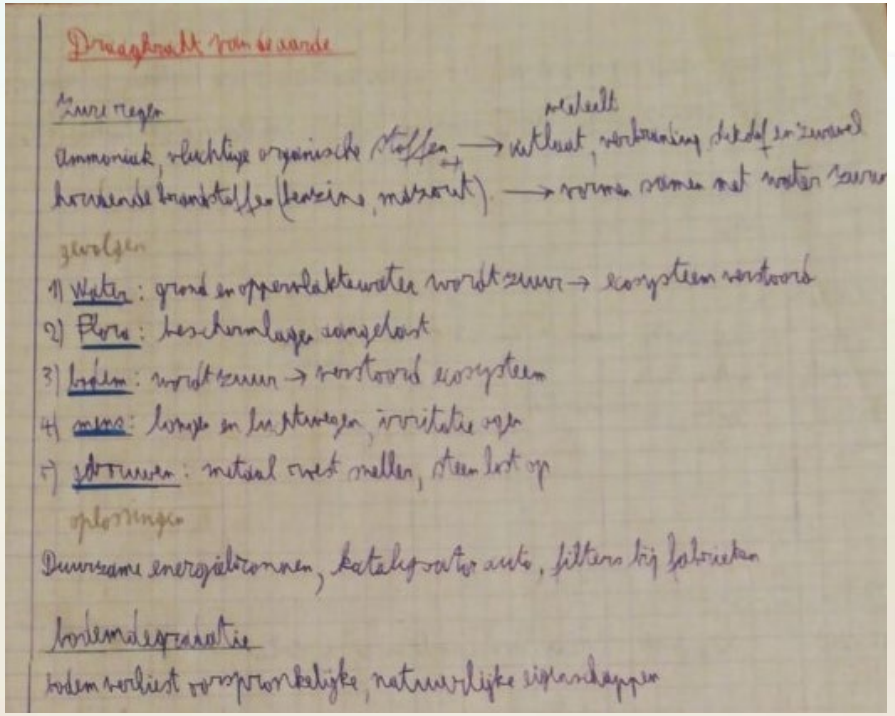
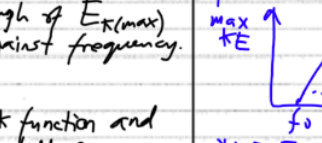
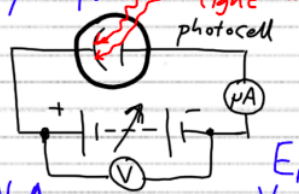
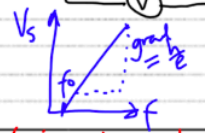
Summarising

Distilling the most important information from a source and reformulating it in one's own words





Topic: PHOTOELECTRIC EFFECT	Name:
Specification Point: 3.2.2.1	Date:
Main question: What is the photoelectric effect and how does Einstein's photoelectric equation define it.	

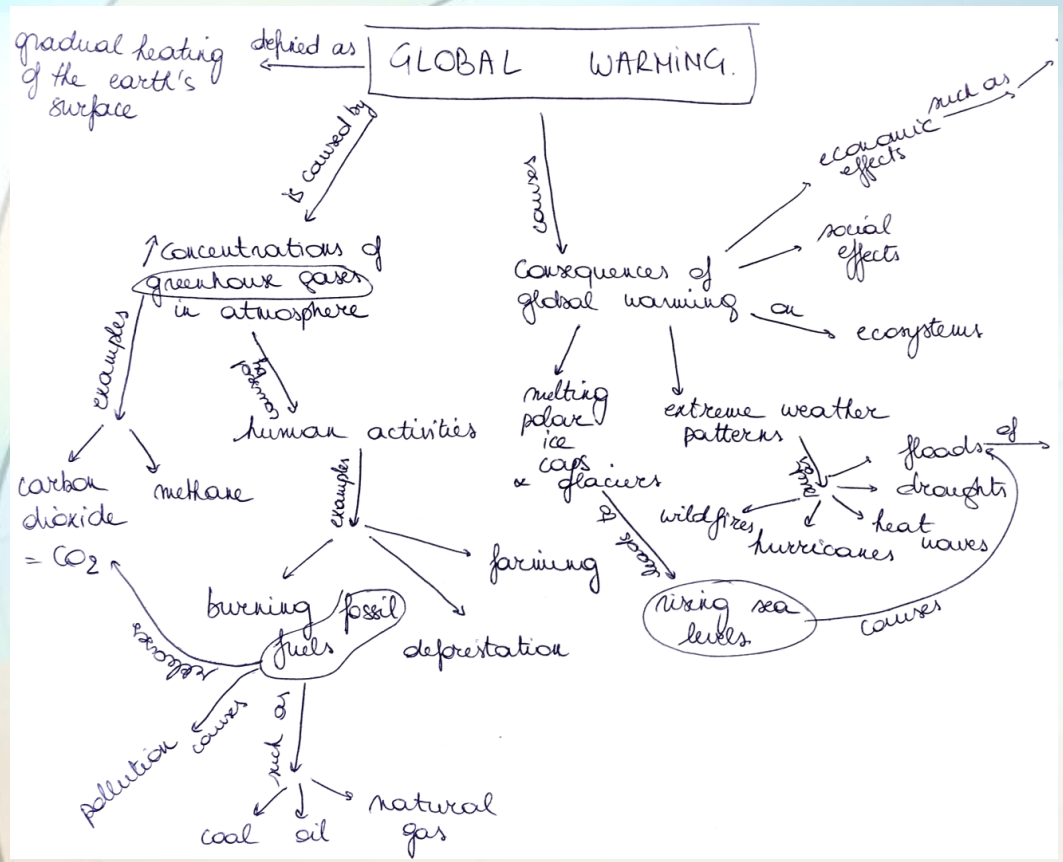
Questions / Key words	Notes / Definitions / Diagrams / Answers
What are photoelectrons?	Electrons (called photoelectrons) are emitted from the surface of a metal when bright light is incident on the metal.
Relationship between intensity and no. of photoelectrons	The higher the *intensity* of the light then the greater the number of photoelectrons emitted. *$I = P/A \Rightarrow W\,m^{-2}$
How frequency affects max KE THRESHOLD FREQUENCY	The frequency of the incident light affects the maximum KE of the photoelectrons. There is a threshold frequency below which no photoelectrons are emitted.
Graph of $E_{K(max)}$ against frequency.	 f_0 is the threshold frequency
Work function and threshold frequency.	$E_{K,max} = hf - \phi$ (Planck's constant $h = 6.63 \times 10^{-34}$ Js; Work function; Einstein's Photoelectric Eqn.) NOTE: $\phi = hf_0$ Work function is the minimum energy needed for a photoelectron to escape the surface.
Evidence that e-m radiation consists of particles.	NOTE: 1 photon interacts with 1 electron so $\phi = hf_0$
Photocell circuit and stopping potential V_s.	 $\lambda = \frac{c}{f}$ The stopping potential is the PD which just stops the photoelectrons so the μA read zero. $E_{K,max} = V_s \times e$
Graph of stopping potential against frequency.	 $eV_s = hf - \phi$ $V_s = \frac{hf}{e} - \frac{\phi}{e}$ $y = mx + c$

Summary

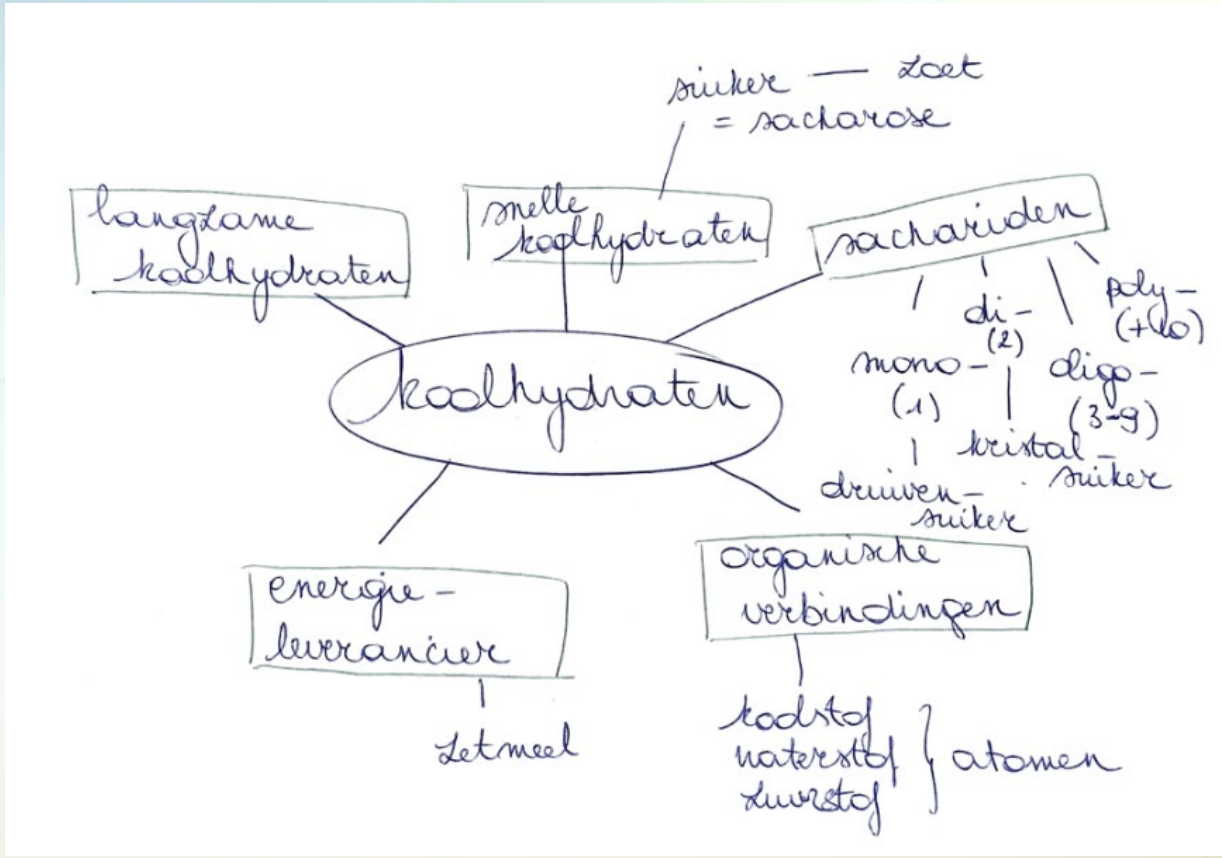
1. The PE effect is when photoelectrons are emitted from the surface of a metal when light with a frequency greater than the threshold frequency is incident upon it.
2. $E_{K(max)}$ is equal to the energy of the photon (hf) minus the work function (ϕ). It does not predict the number of photoelectrons emitted: that depends on the intensity of the light.

Mapping

Distilling the most important concepts from an information source and organising them so that the (inter)relationships are visually clear via graphical connections, often lines or arrows



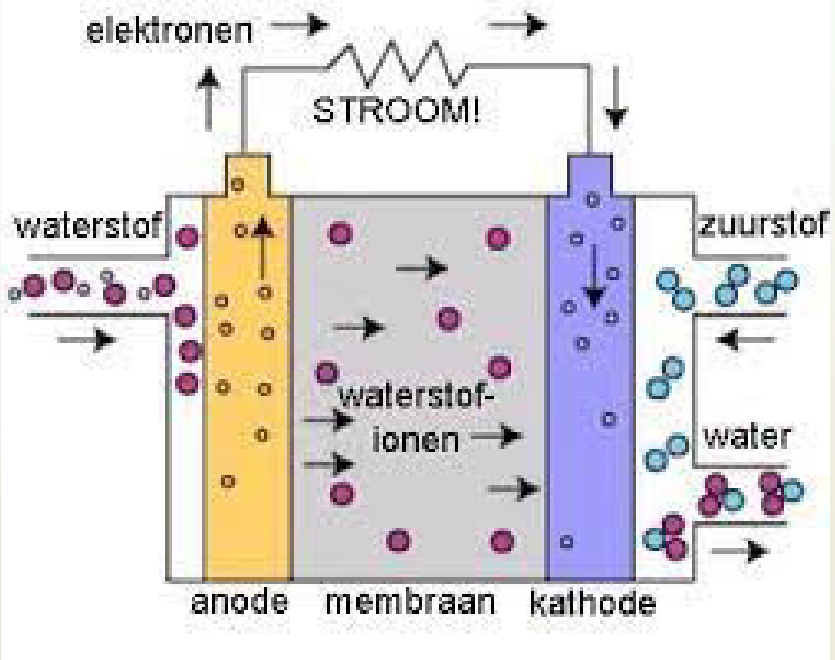
Concept map



Mind map

Drawing

Converting textual material (verbal information) into the form of a drawing (visual information)



Imagining

Consciously forming a mental image of the information read or listened to

Self-testing

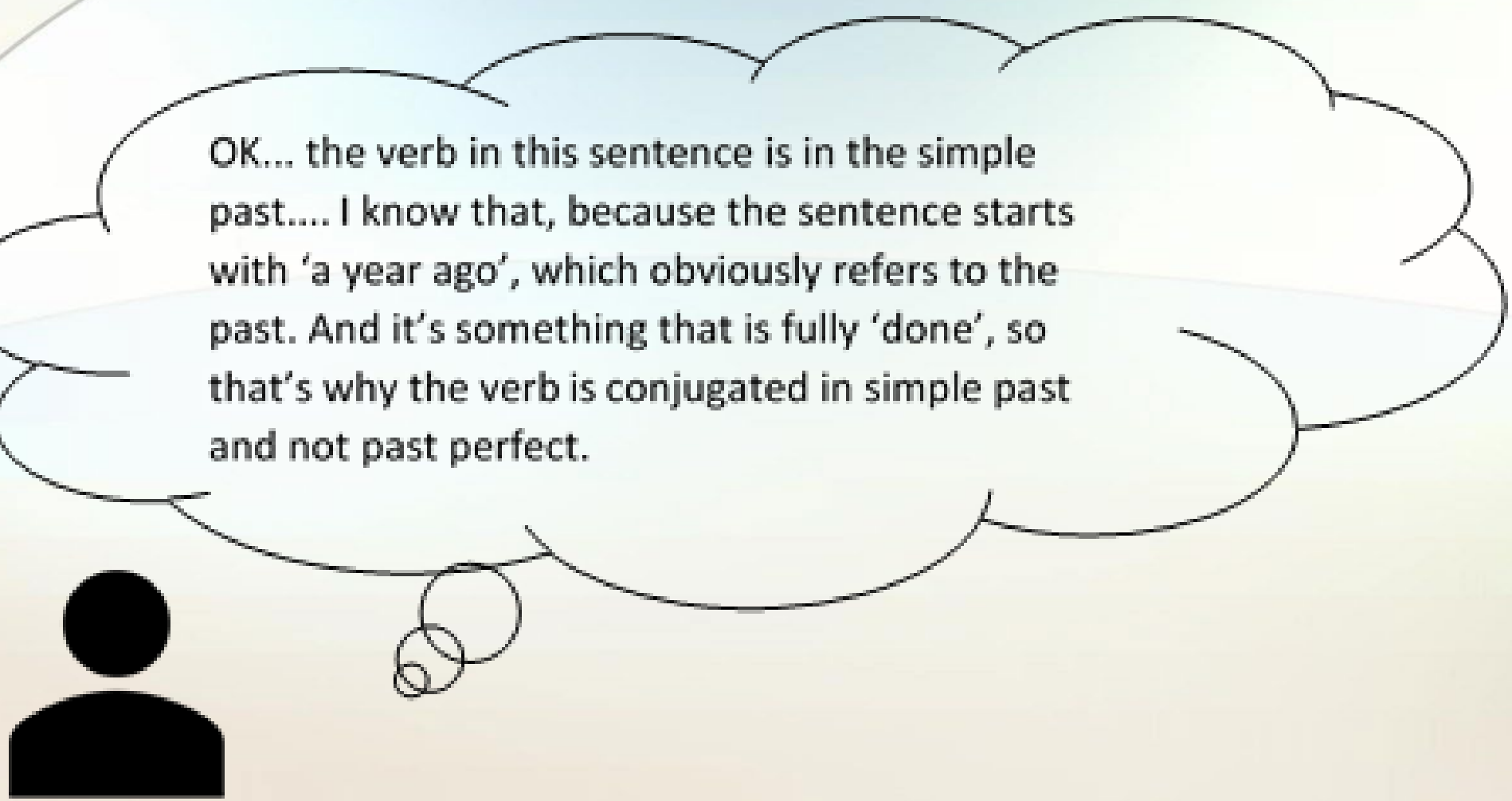
Trying to recall something one has learnt (i.e., from long-term memory) by testing oneself about it

Leg het verschil uit tussen nominale en reële rente.	Leg de samenhang tussen prijs, afzet en omzet uit.	Wat is intergenerationele ruil?	Verklaar de invloed van inflatie op sparen en lenen.
Verklaar het begrip oligopolie.	Noteer alles wat je weet over welvaartsvaste pensioenen.	Waarom kan de collectieve aanbodlijn verschuiven als gevolg van heffingen of subsidies?	Wat is de invloed van marginale opbrengsten en marginale kosten op de winst?
Verklaar het effect van octrooien op de markt.	Op welk moment draait een onderneming break-even?	Wat is het verschil tussen publiek en privaat kapitaal?	Leg uit: prijselasticiteit.

Vorige week (1 punt)	**2 weken geleden (2 punten)**	**Vorige maand (3 punten)**	**Langer geleden (4 punten)**

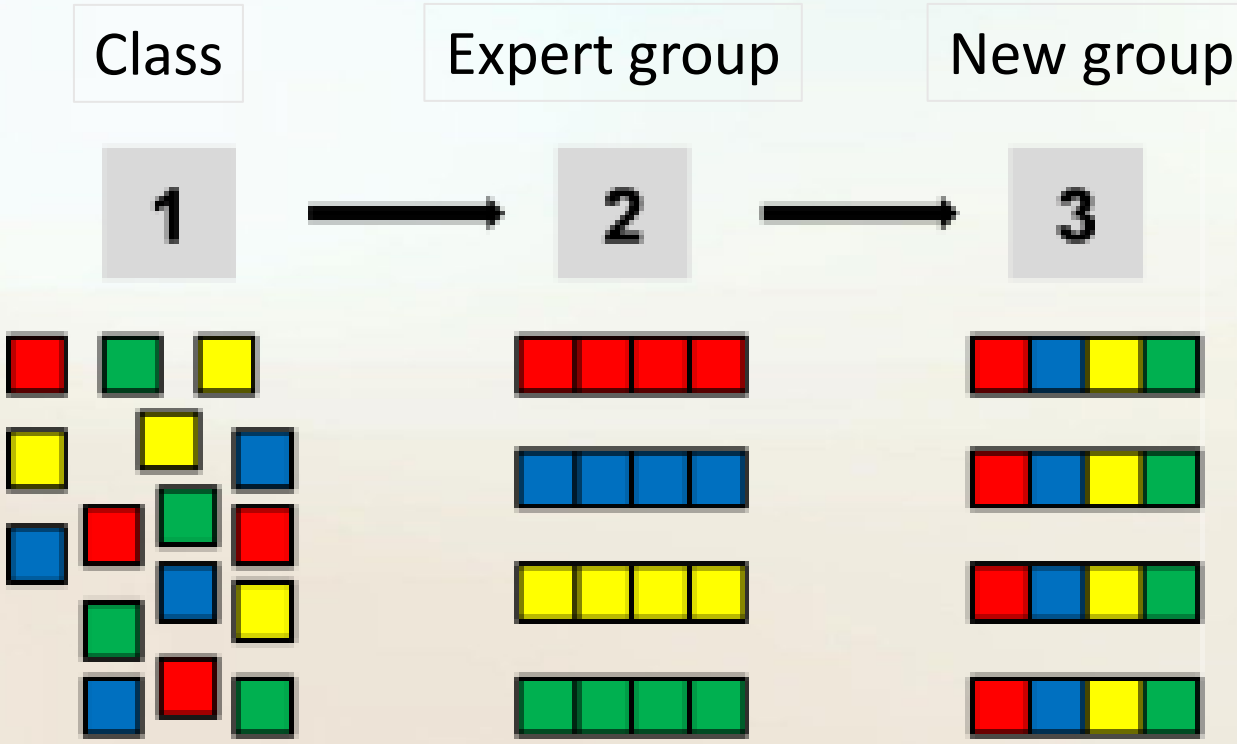
Self-explaining

Generating explanations (i.e. explaining something) during learning so that relevant prior knowledge is activated and integrating and organising the new information becomes easier.


OK… the verb in this sentence is in the simple past…. I know that, because the sentence starts with ‘a year ago’, which obviously refers to the past. And it’s something that is fully ‘done’, so that’s why the verb is conjugated in simple past and not past perfect.

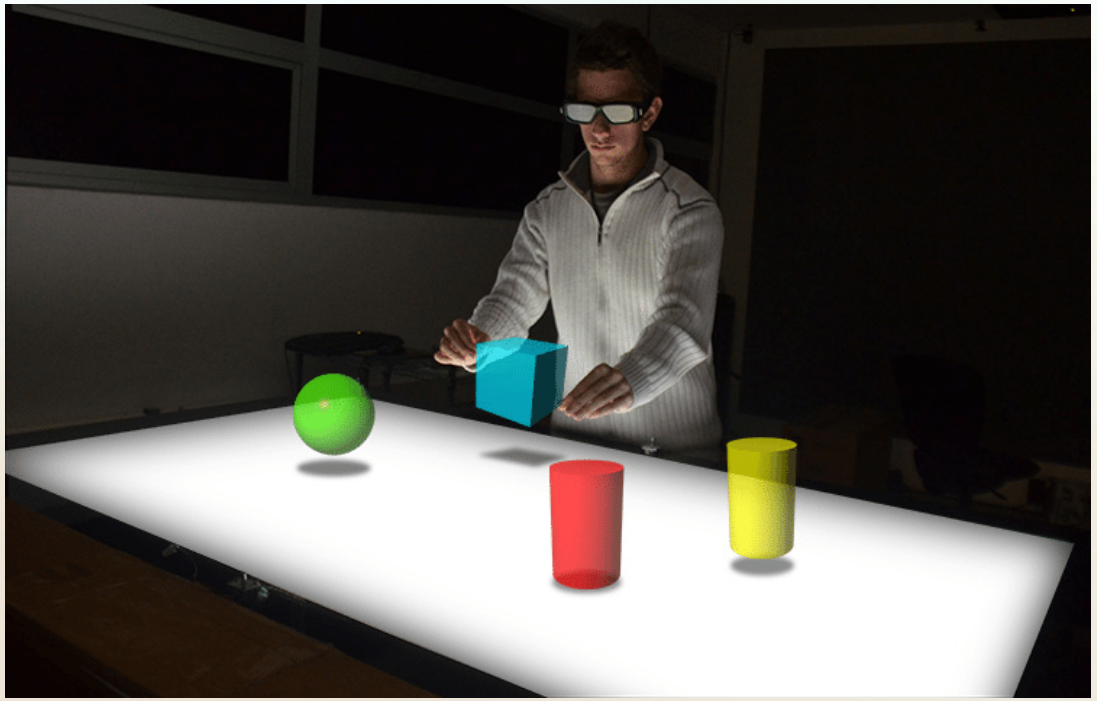
Teaching

Explaining the subject matter studied to someone else (real or fictional)

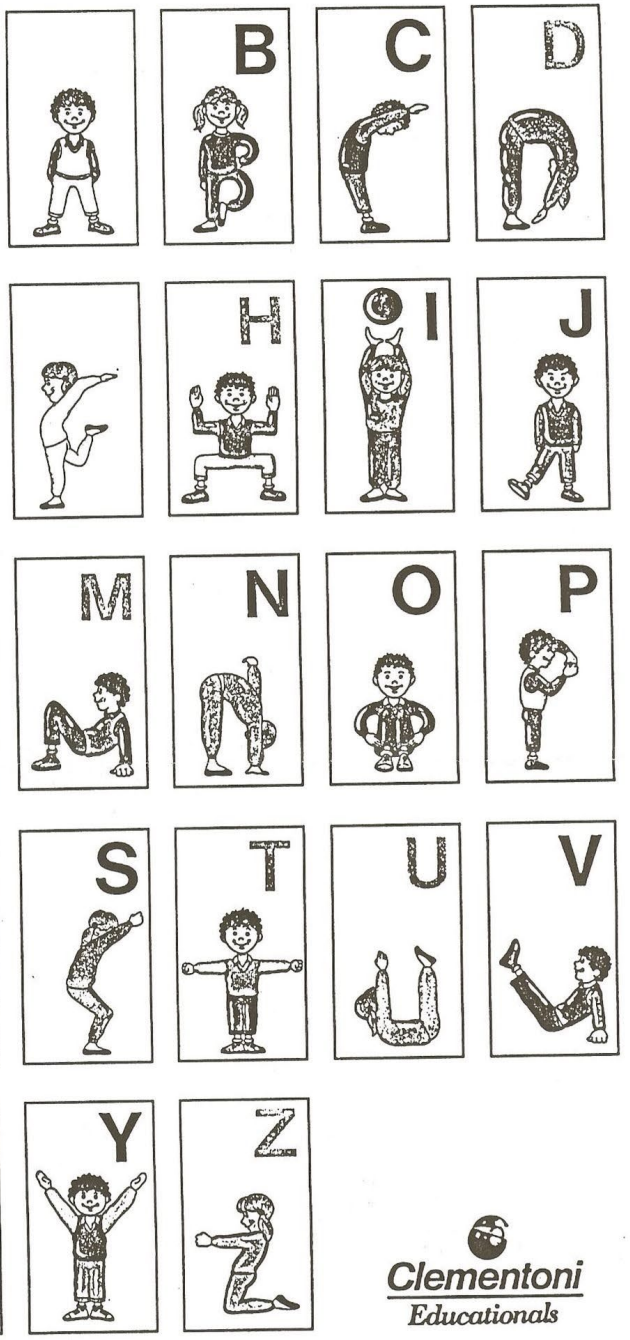


Enacting

Manipulating objects or performing task-relevant movements or gestures related to what one is trying to learn



HET LICHAAMSALFABET is een leuke, nieuwe en dynamische manier om met elkaar te spreken. Je doet het namelijk met je lichaam. Daarmee beeld je de letters van het alfabet uit. Zo word je spelenderwijs geconfronteerd met de mogelijkheden en onmogelijkheden van houdingen en bewegingen.



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Brod

- Concept mapping
- Explaining
- Predicting
- Questioning
- Testing
- Drawing

Brod, G. (2021). Generative learning: Which strategies for what age? *Educational Psychology Review, 33*(4), 1295-1318.

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