18th Advanced Course - Archives Jean Piaget

Factors of Working Memory Development : The Time-Based Resource-Sharing Approach

Valérie Camos

Université de Bourgogne & Institut Universitaire de France

Pierre Barrouillet

Université de Genève

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Working Memory and Piaget

- Dark side of « measuring performance »
- Coordination ≈ WM

- Thanks to the Neo-piagetians

Contents:

The Time-Based Resource-Sharing Model: An overview

Time-Based Resource-Sharing Model

Barrouillet & Camos, 2007

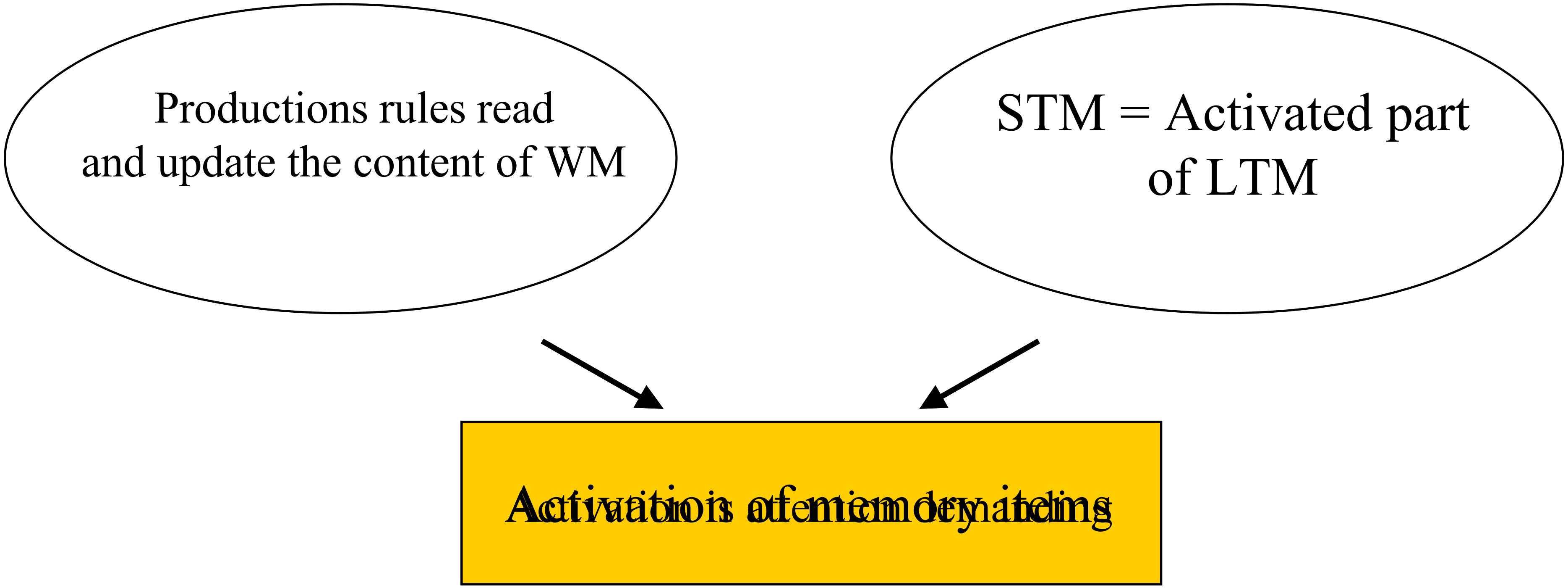
- Processing and storage both require attention, which is a limited resource.
- Outside the focus of attention: Time-related decay of memory traces
- Possible refreshing by attentional focusing (Cowan, 1995)
- **Only one element at a time** (Oberauer, 2003; Garavan, 1998)
- Consequence: memory traces fade away during processing episodes
- **Rapid switching between processing and maintenance**

Processing and storage require attention

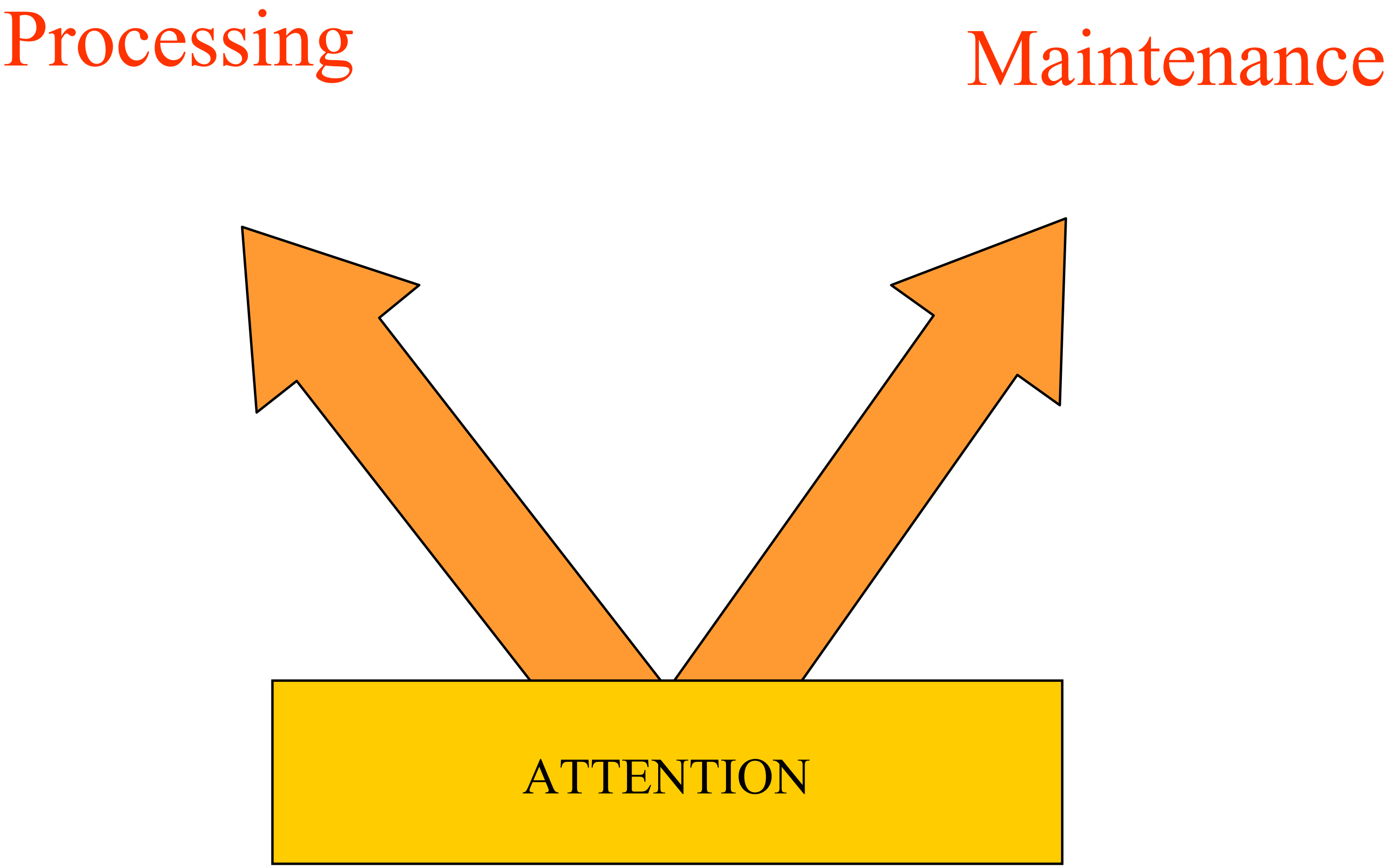
Anderson's ACT-R Framework

Processing

Maintenance



Processing and storage require attention



When attention is switched away, activation suffers from a time-related decay

- Activation is produced by attentional focusing (Cowan, 1995).
- Activation declines as soon as the focus of attention is switched away.
- While processing captures attention, relevant information declines in STM
- When attention is used to refresh decaying memory traces, processing is temporarily suspended.

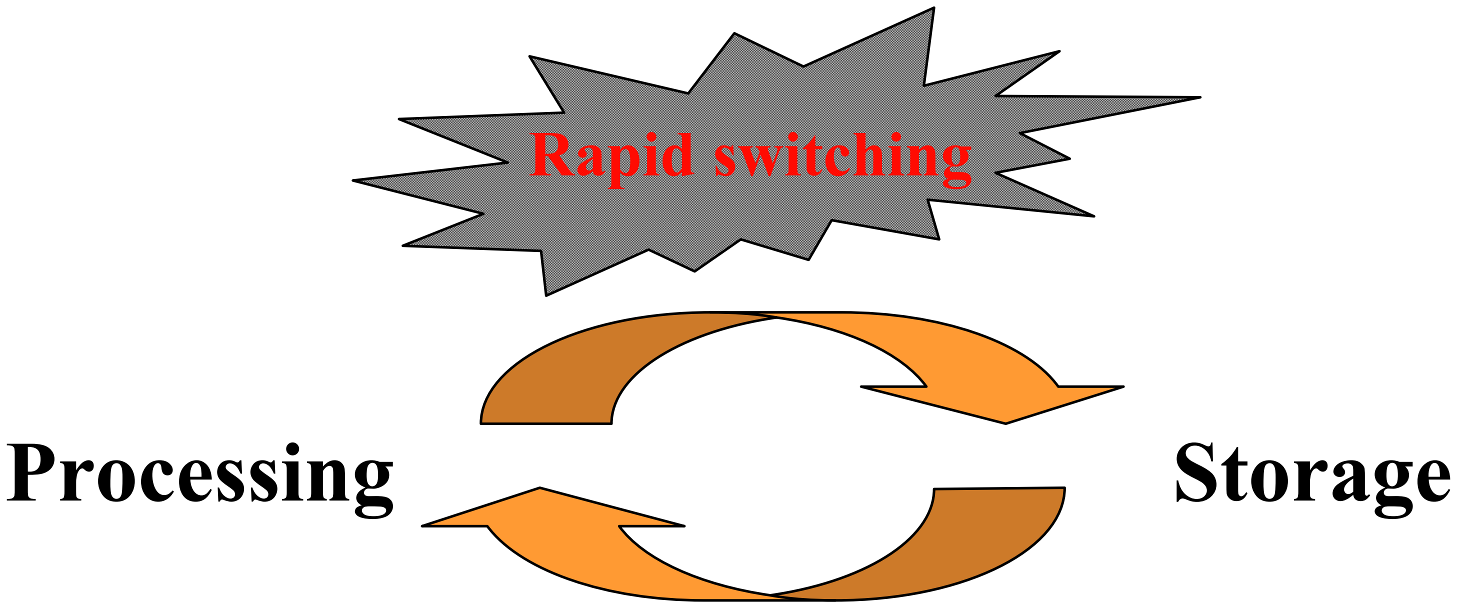
Refreshing of the decaying memory traces through attentional focusing

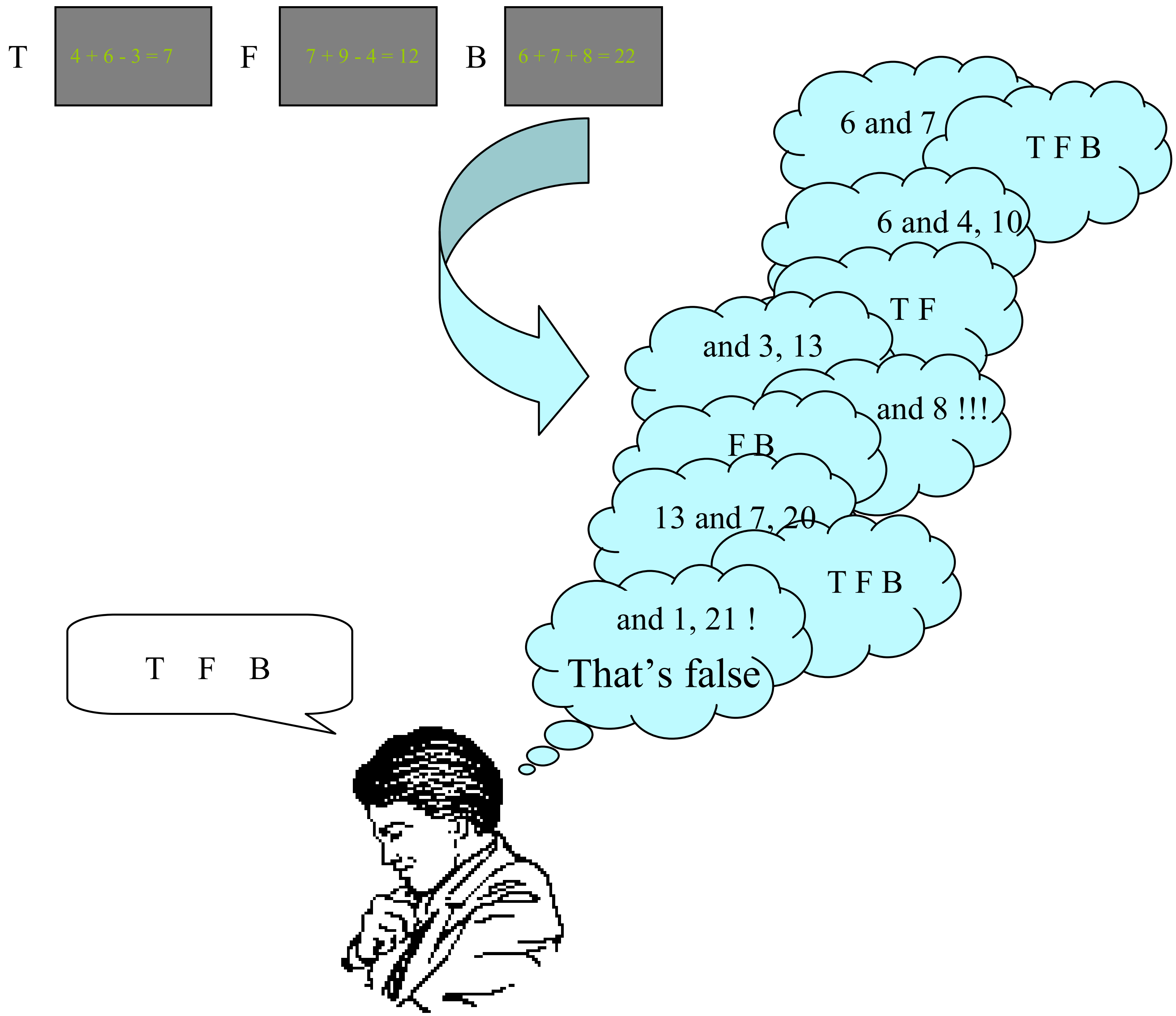
• The refreshing of the decaying memory traces in STM necessitates their reactivation through attentional focusing, but

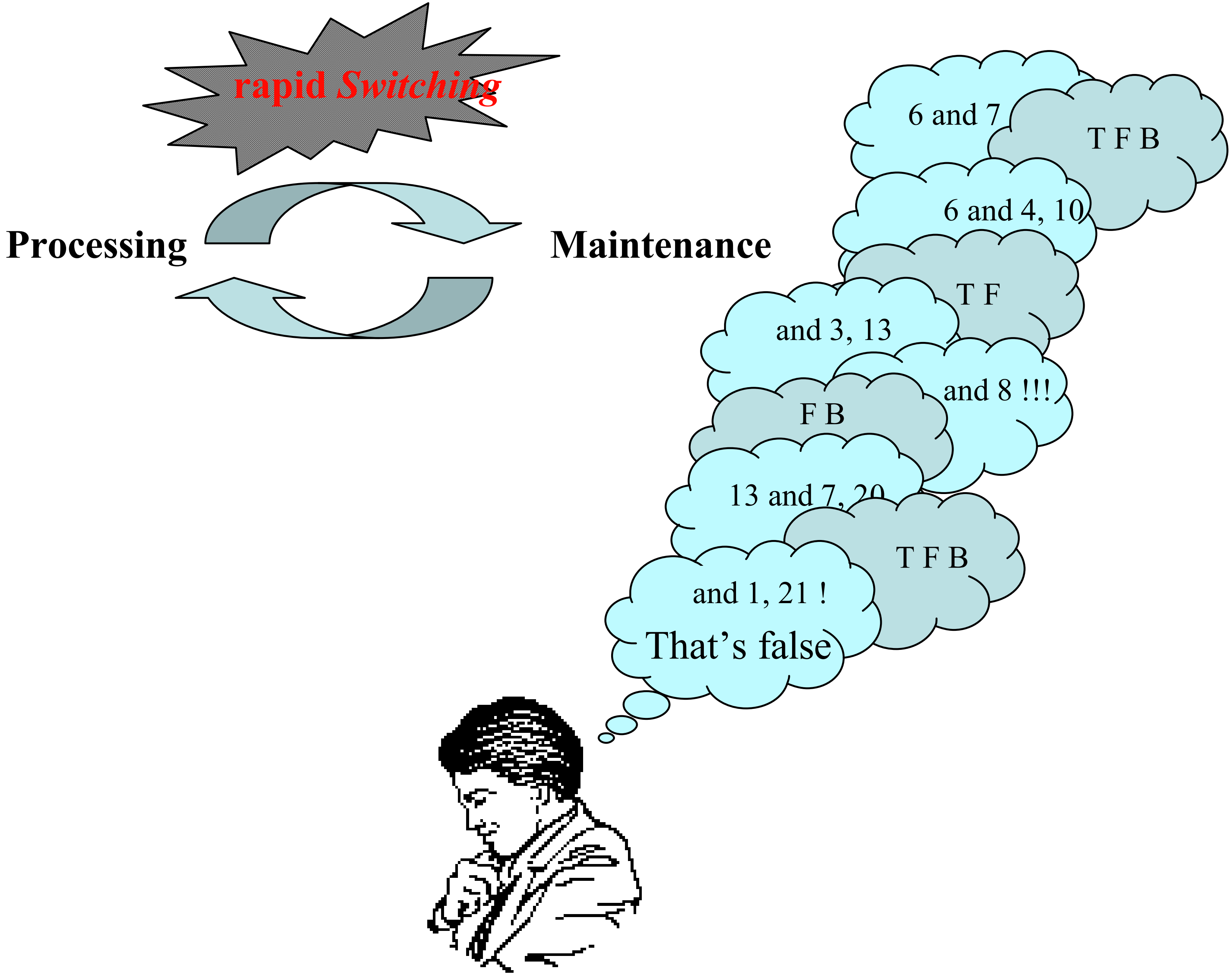
• Attention can be focused to only one element at a time (Oberauer, 2003; Garavan, 1998)

Sharing attention is time-based

Time-Based Resource-Sharing Model




T
4 + 6 - 3 = 7
F
7 + 9 - 4 = 12
B
6 + 7 + 8 = 22
6 and 7
T F B
6 and 4, 10
T F
and 3, 13
and 8 !!!
F B
13 and 7, 20
T F B
and 1, 21 !
That’s false
T F B


rapid *Switching*
Processing
Maintenance
6 and 7
T F B
6 and 4, 10
T F
and 3, 13
and 8 !!!
F B
13 and 7,
T F B
and 1, 21 !
That’s false

Time-Based Resource-Sharing model and Cognitive Load

What is cognitive load ?

The proportion of time during which a given activity captures attention in such a way that the refreshing of memory traces is impeded.

A metric for cognitive load

$$\text{Cognitive load} = \frac{\text{Duration of attentional capture}}{\text{Total time allowed}}$$

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

Testing the Time-Based Resource-Sharing model: A paradigm

Computer-paced WM span tasks

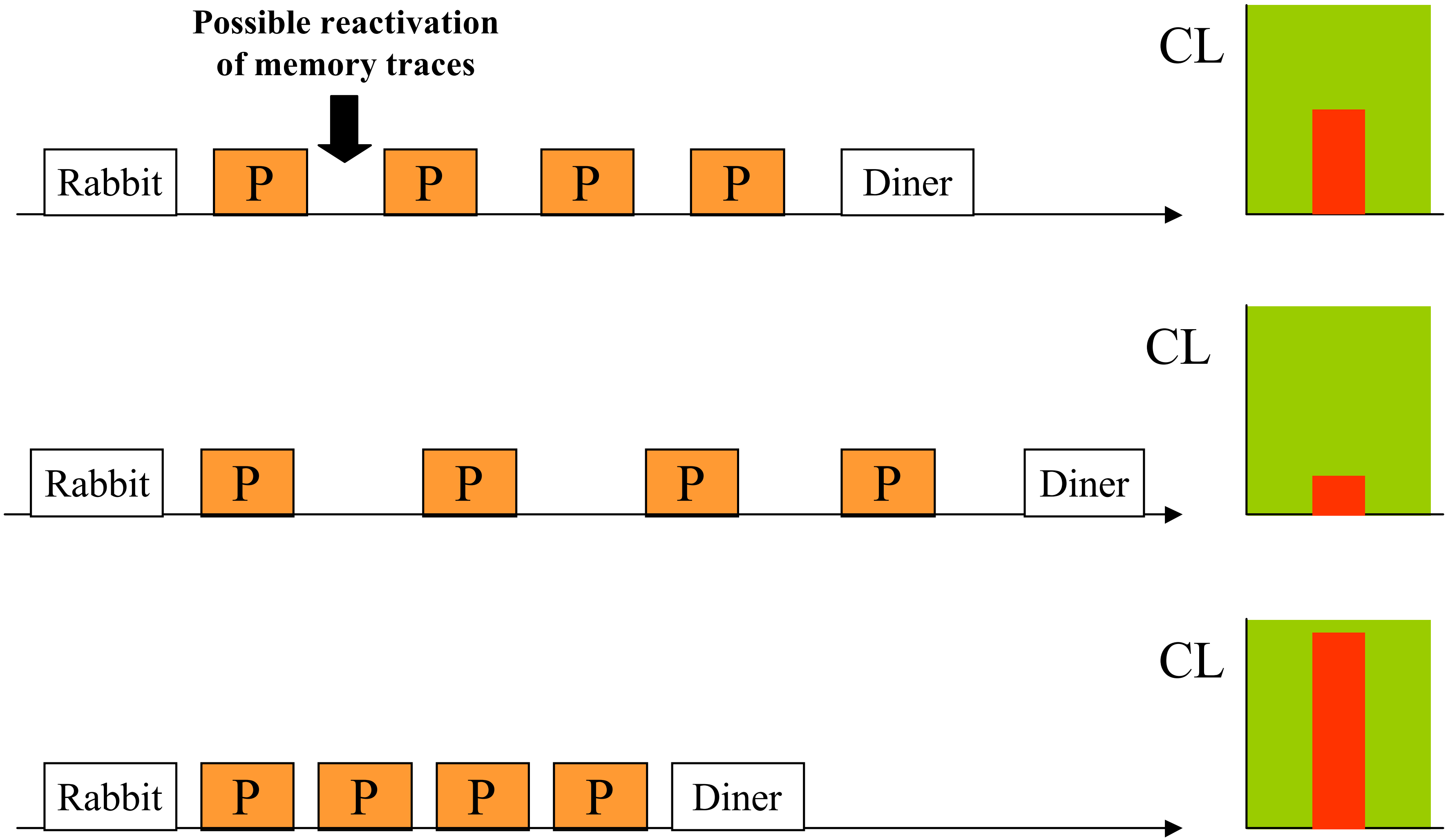
Maintaining items while performing a task

A model of daily life mental activities

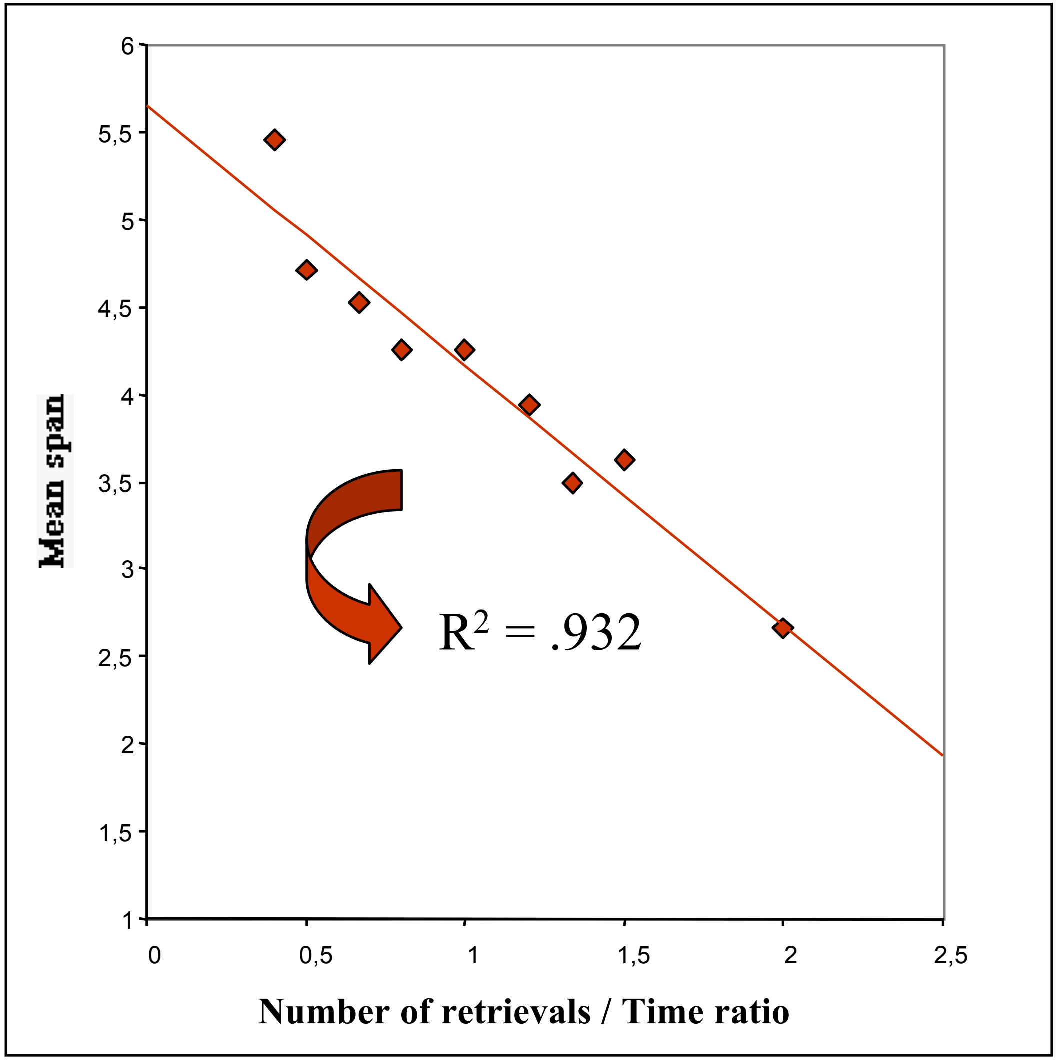
A good laboratory to study WM functioning

Control the time course of cognitive activities:
Manipulating switching and decay

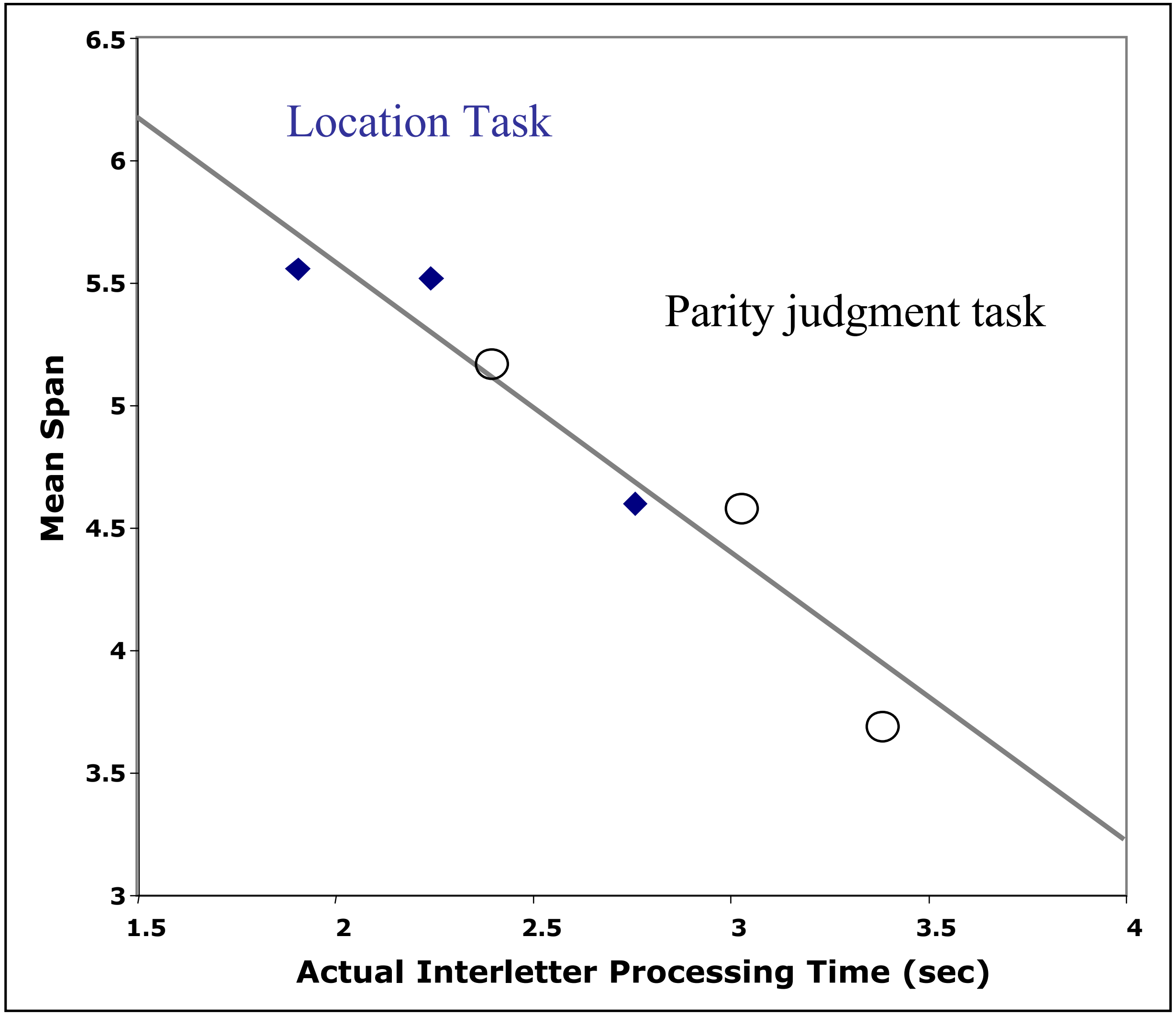
Switching mechanism and decay



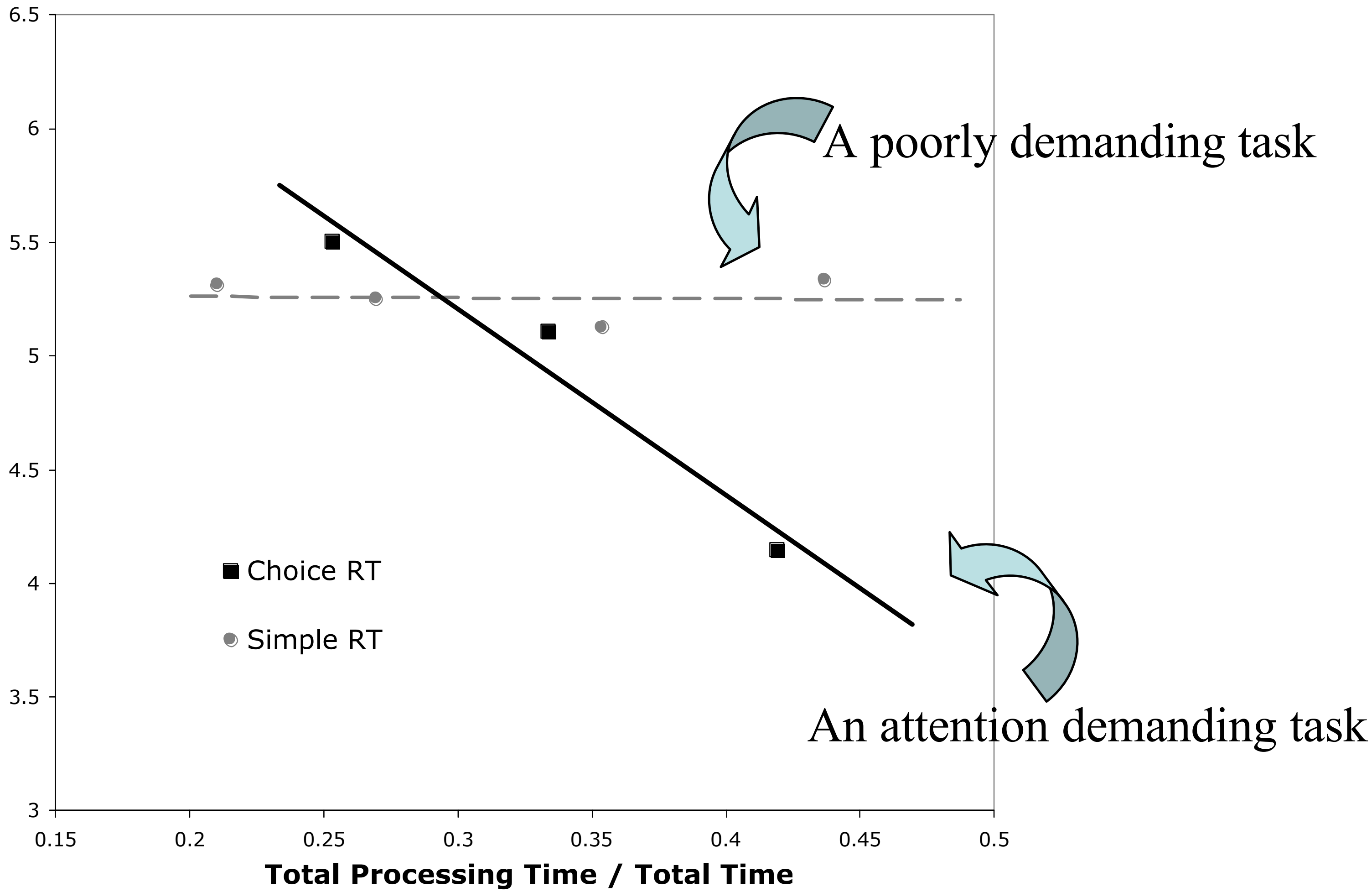
Some evidence….



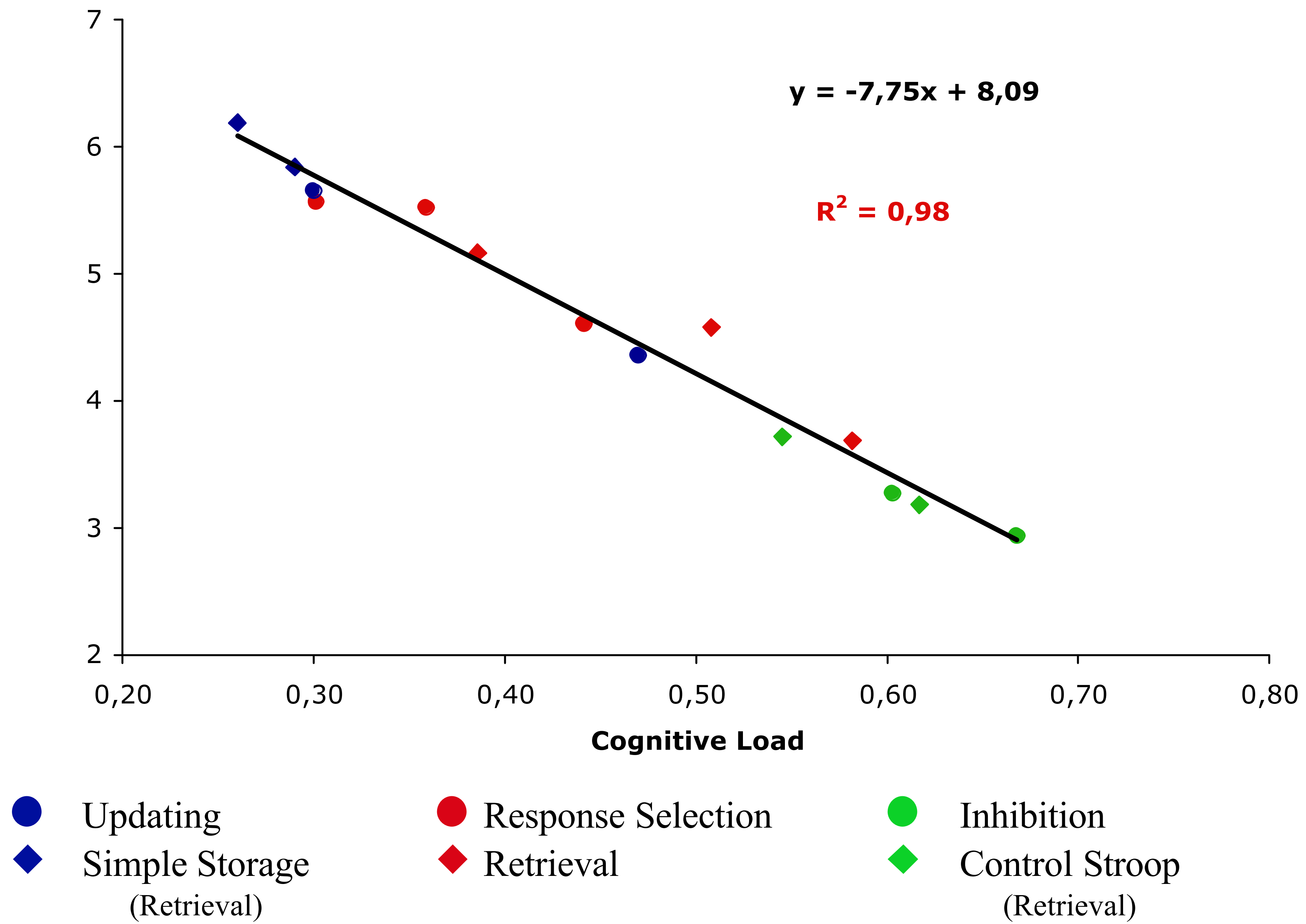
Barrouillet, Bernardin, & Camos, 2004, JEP:G, Exp.7



Barrouillet, Portrat, Bernardin, Vergauwe, & Camos, 2007, JEP:LMC, Exp. 3



Barrouillet, Portrat, Bernardin, Vergauwe, & Camos, 2007, JEP:LMC, Exp. 4

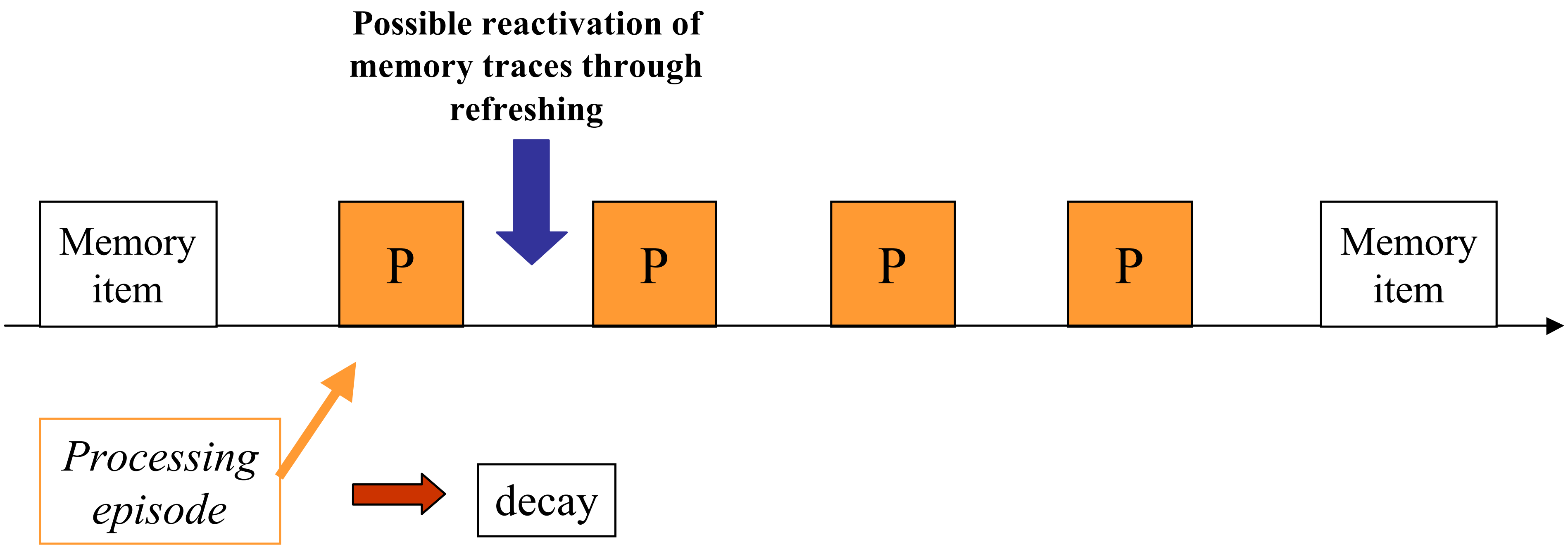


Portrat, Camos, & Barrouillet, in prep.

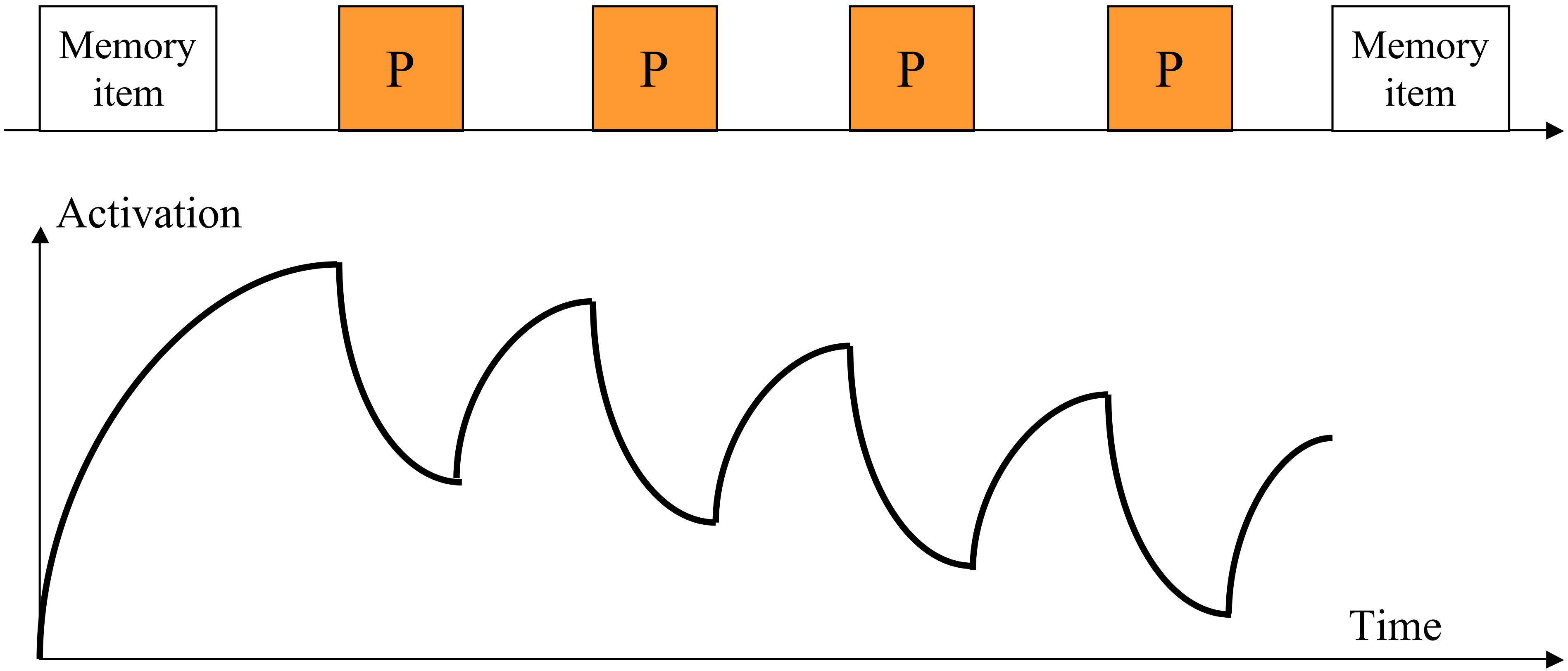
The factors that underpin the developmental increase in Working Memory spans

Rapid switching between processing episodes

Processing activities do not occupy attention continuously
but during successive episodes



The Time-Based Resource-Sharing model
Decay and Refreshing

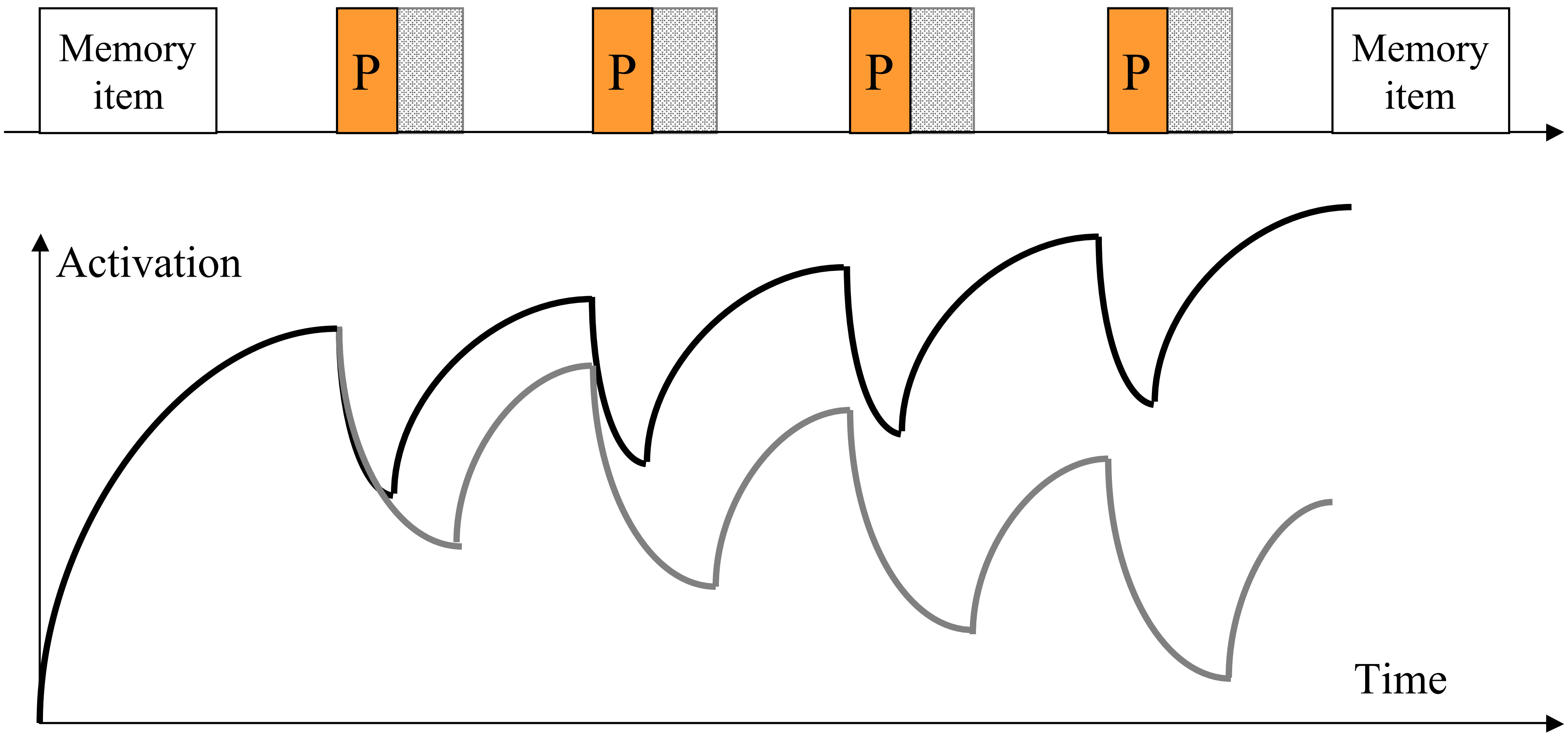


3 sources of developmental differences

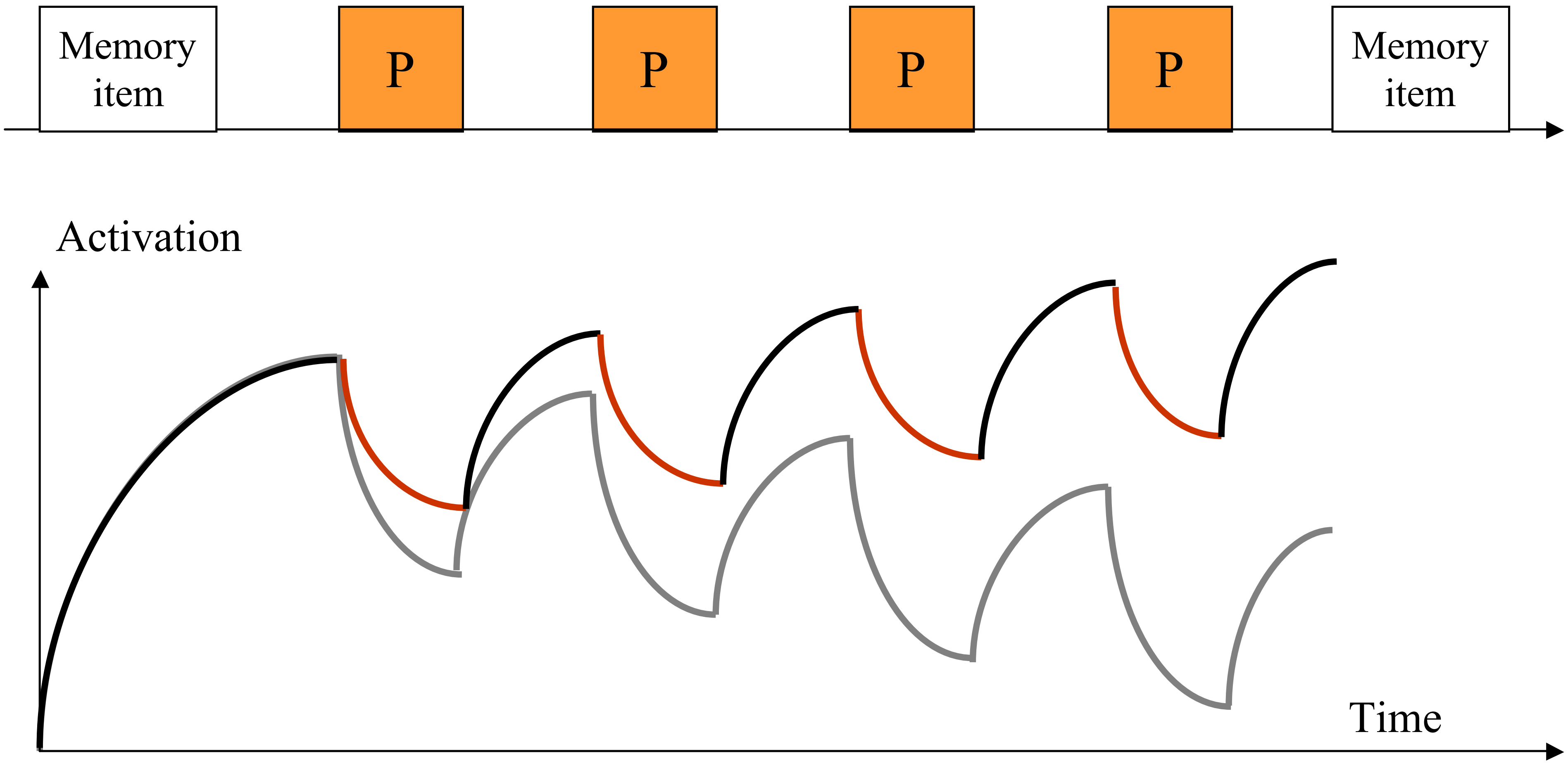
- The amount of available attention
- The speed of decay
- The efficiency of refreshing

Increase in attentional capacities

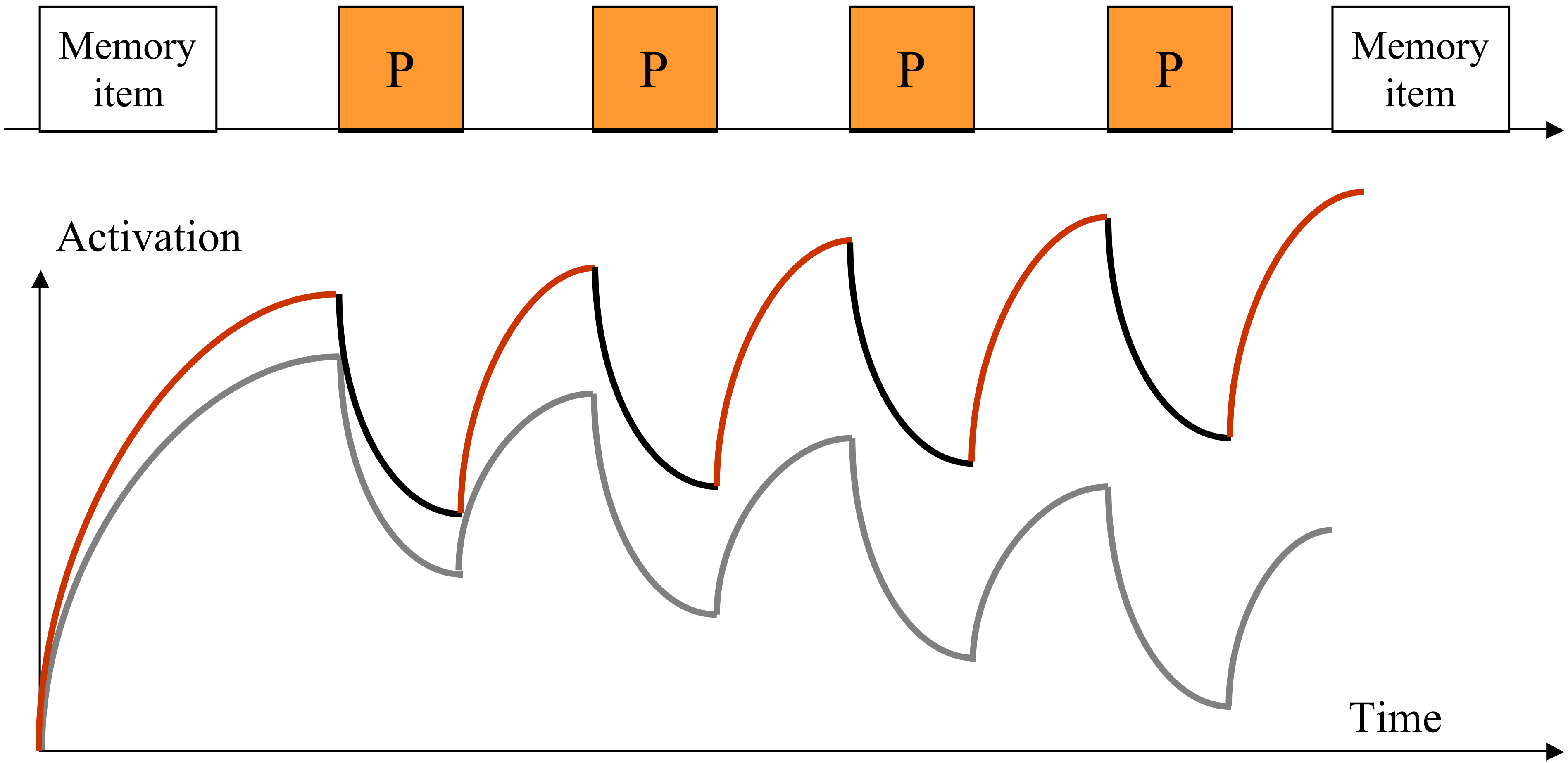
→ Faster processing



Slower decay



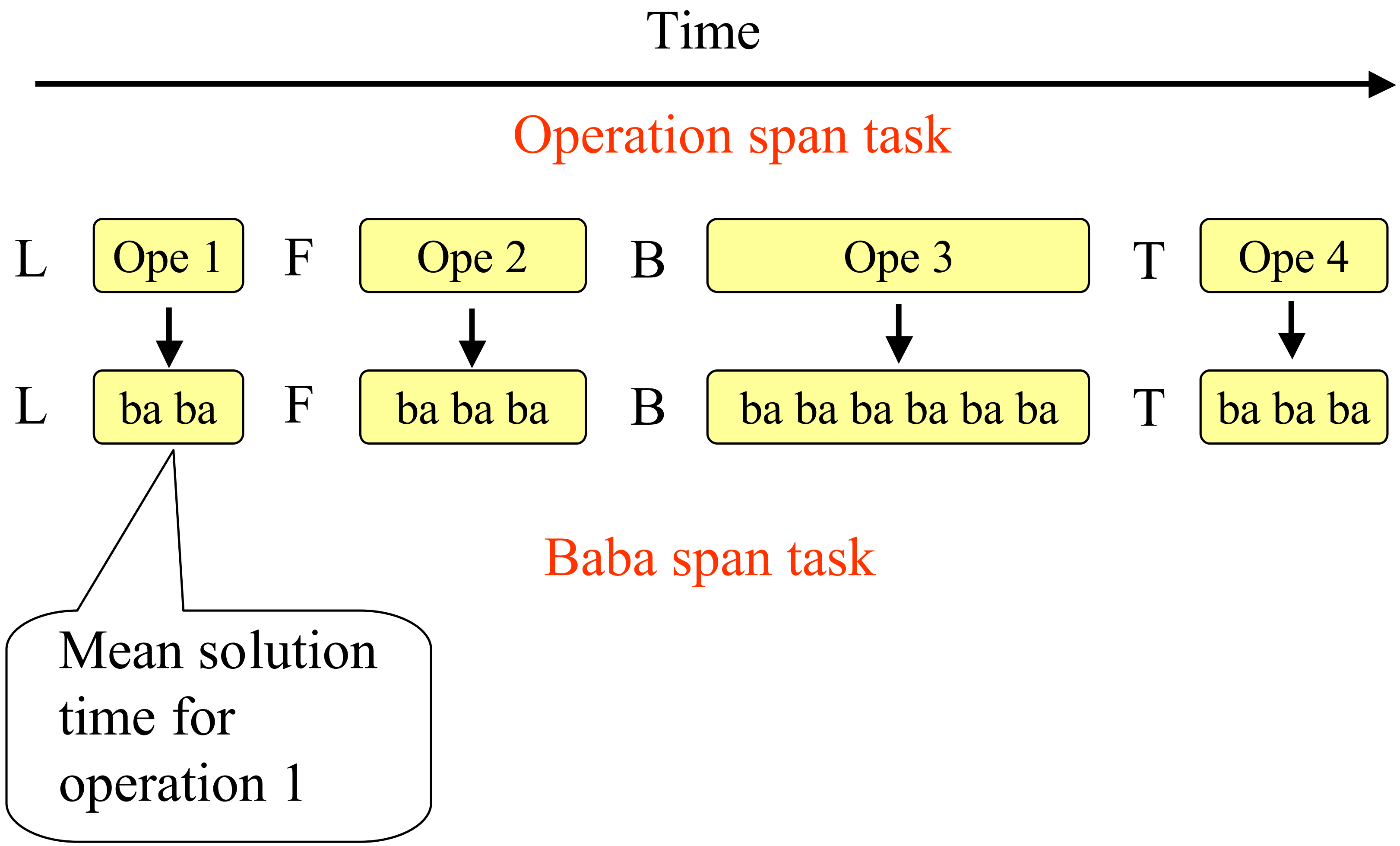
Increase in refreshing efficiency



The amount of attentional resource

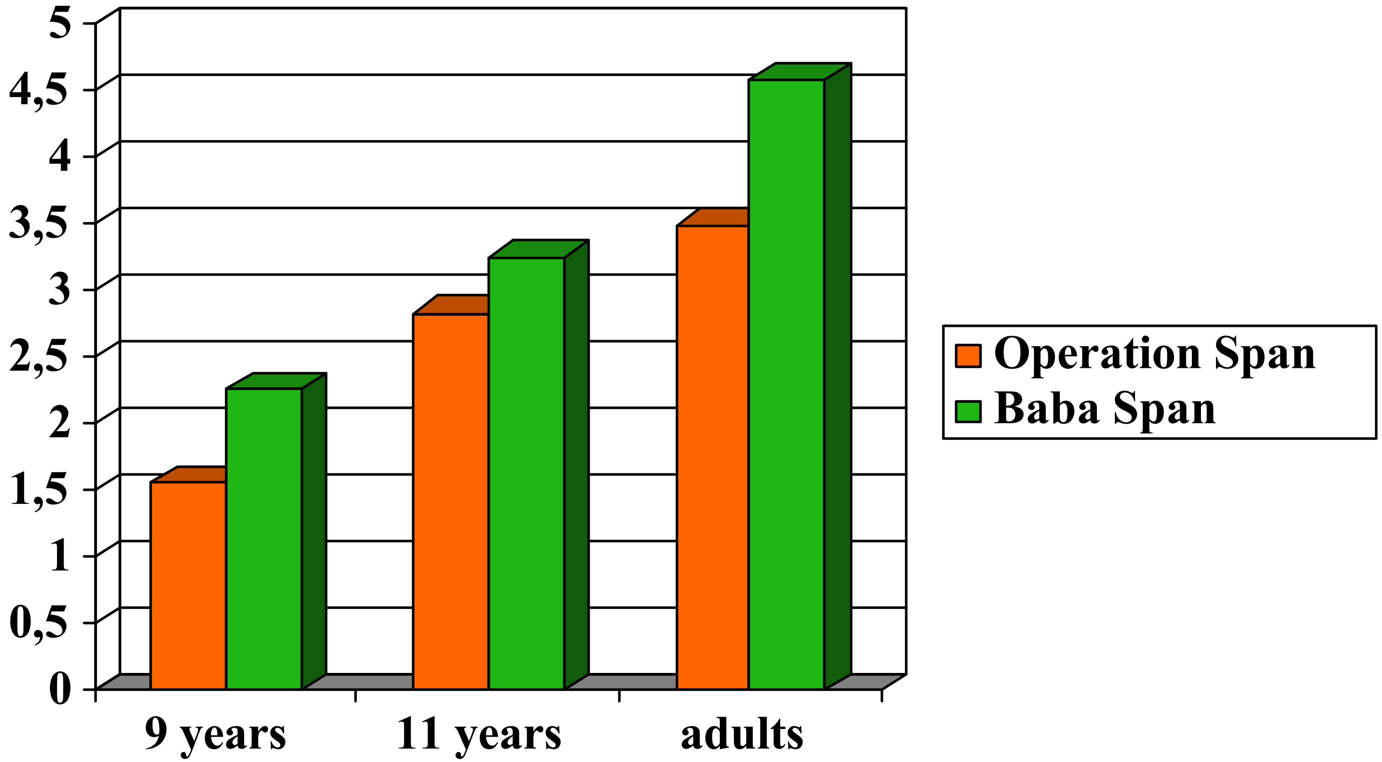
The new paradigm in children

Barrouillet & Camos, 2001, JML, Exp. 3



The results in children and adults

Barrouillet & Camos, 2001, JML, Exp. 3



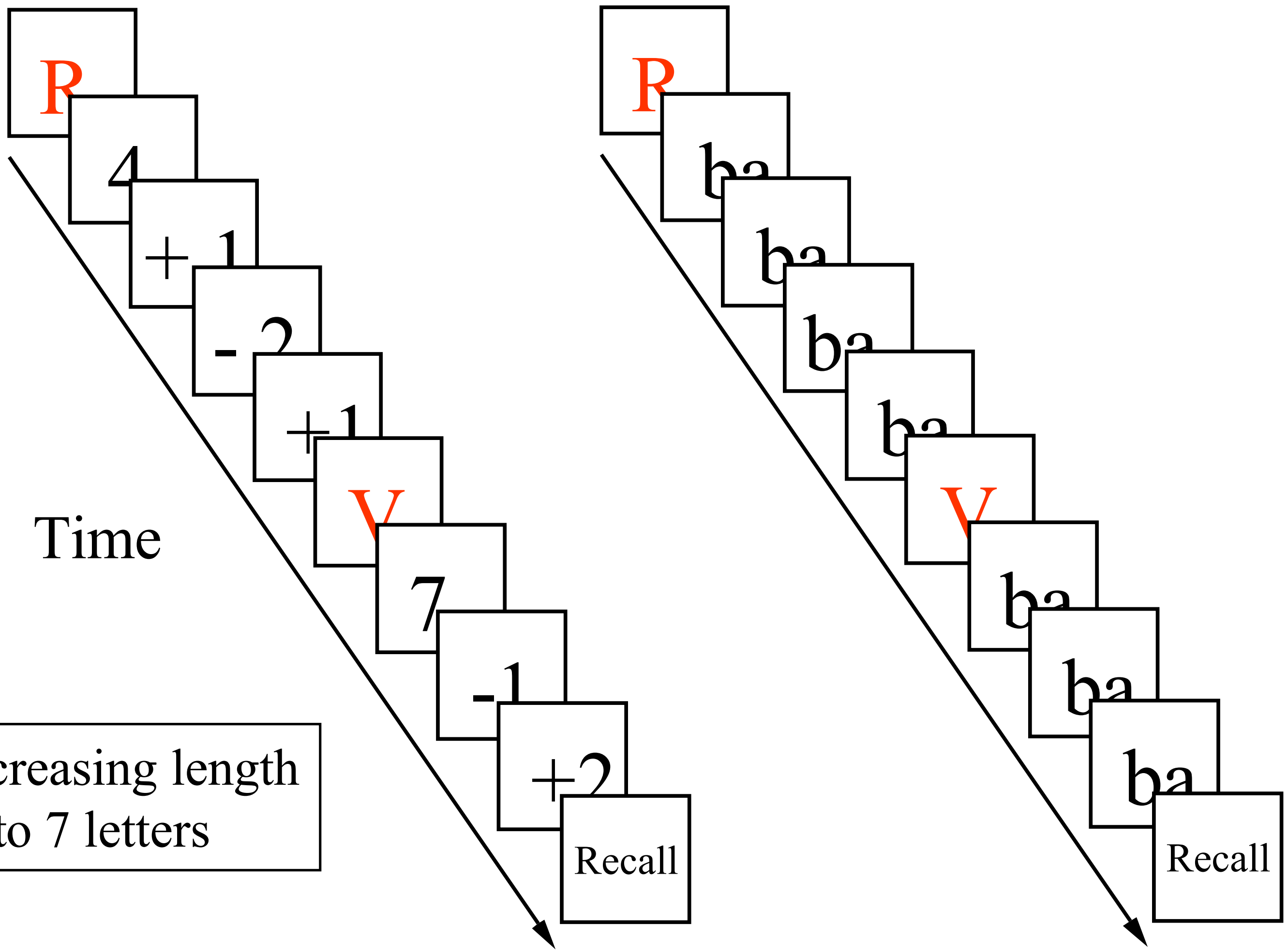
Exp. 1
Conclusions

We cannot jettison any notion of cognitive resource to account for performance in working memory tasks.

Solving problems instead of saying « ba ba » did not result in any dramatic decrease in span.

Individuals can switch attention from the operations to the letters to be remembered while solving operations

Exp. 2: Continuous Operation Span (COS) and Baba span



Series of increasing length from 1 to 7 letters

Gavens & Barrouillet, 2004, JML, Exp. 1

Exp. 2 : Controlling for the duration

Design:

2 tasks: COS, Baba

2 durations but same pace : 2 or 4 operands for 2350 ms each

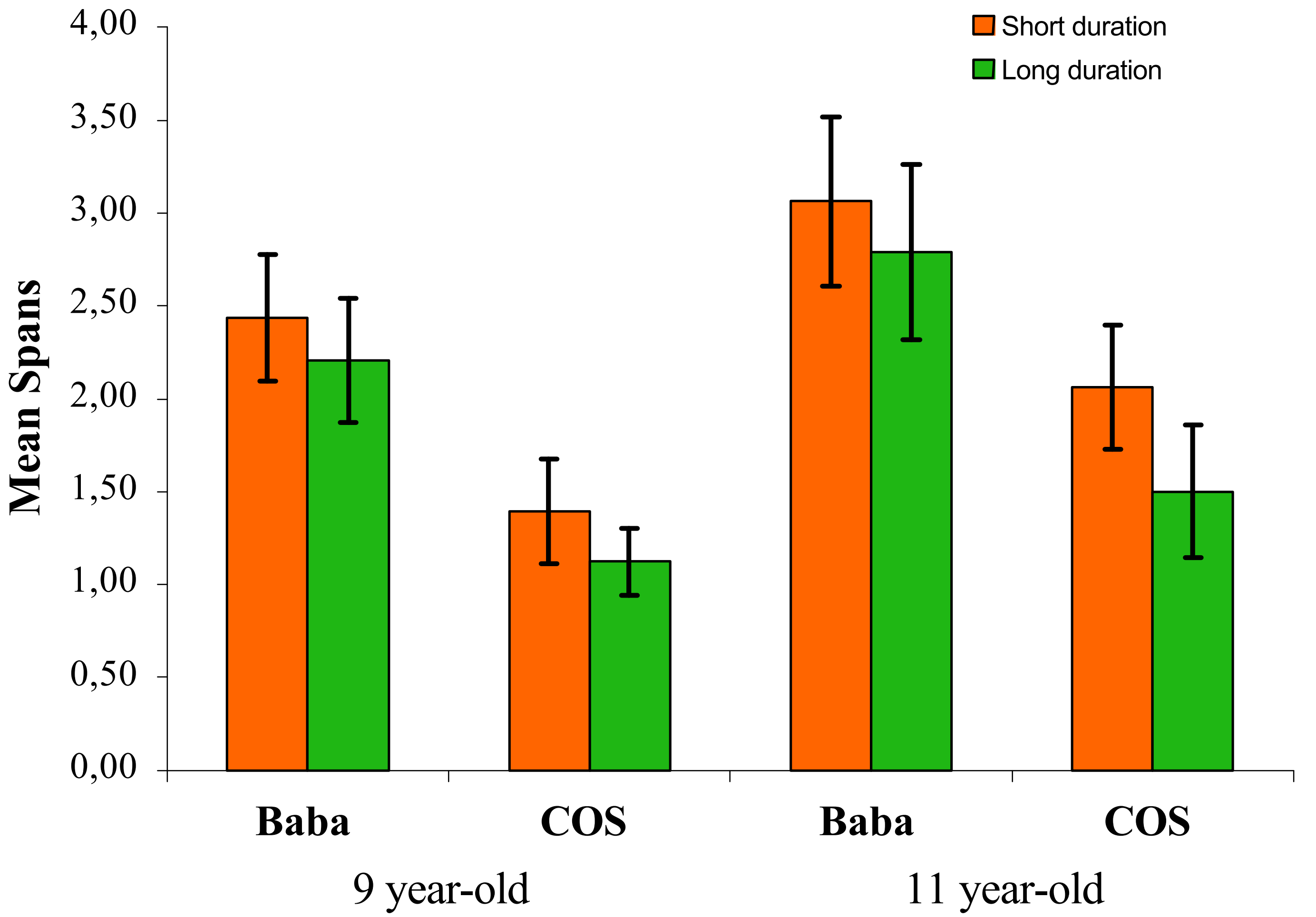
Baba: same number of syllables (10 vs. 17 syllabes)

Participants:

2 groups of 64 children aged 9

2 groups of 64 children aged 11

Results



Gavens & Barrouillet, 2004, JML, Exp. 1

Exp. 2
Conclusions

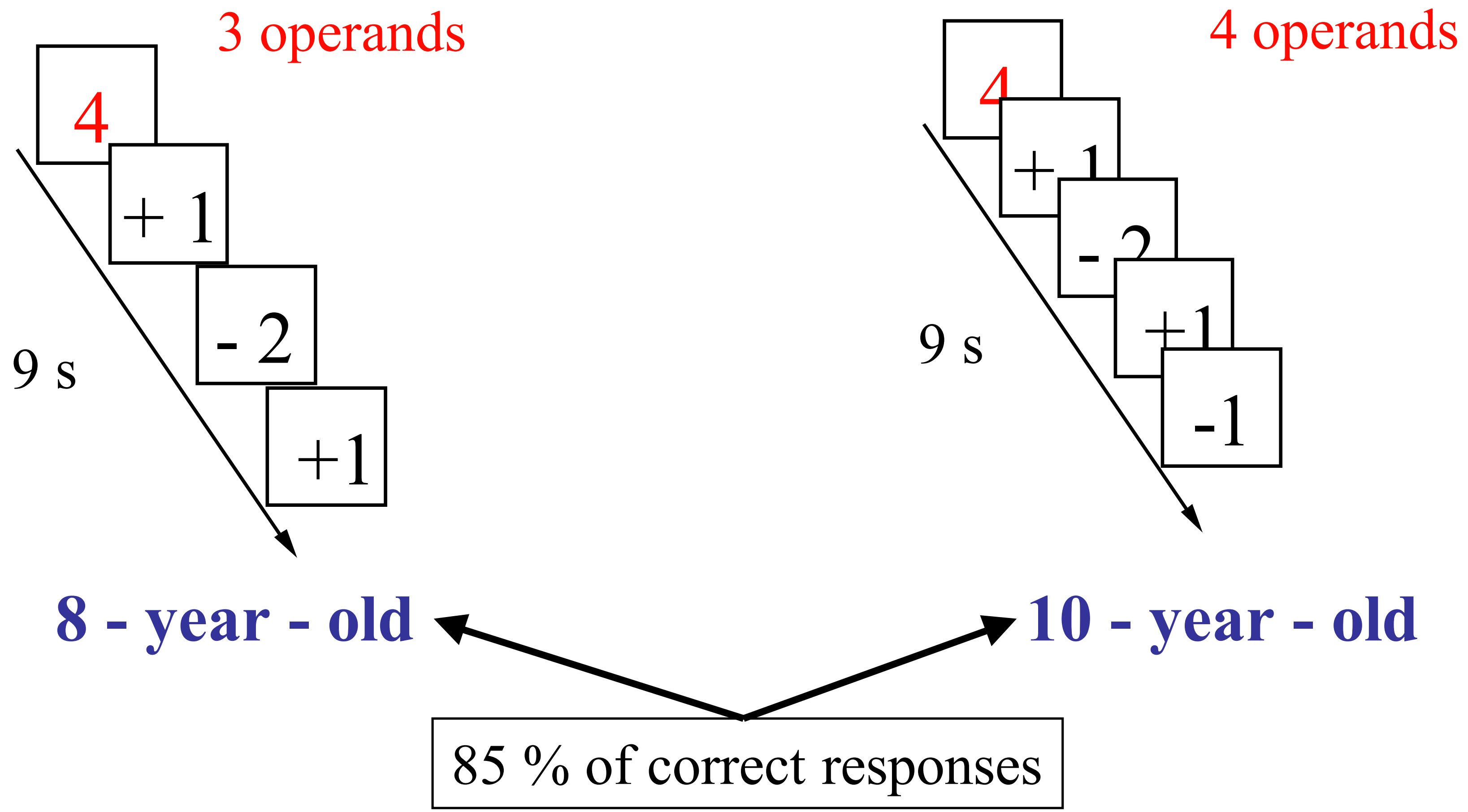
When duration are equated,
older children still outperform younger children.

Equating duration leads to reduced developmental effect, compare to Exp. 1.

↓

Shorter delays of retention could only account for a part of the developmental increase in WM spans

Exp. 3: Equating the difficulty of Continuous Operations across age



Gavens & Barrouillet, 2004, JML, Exp. 3

Experiment 3

Design:

2 tasks: COS, Baba

COS: 3 operands for the younger, 4 operands for the older children within interletter intervals of 9 s.

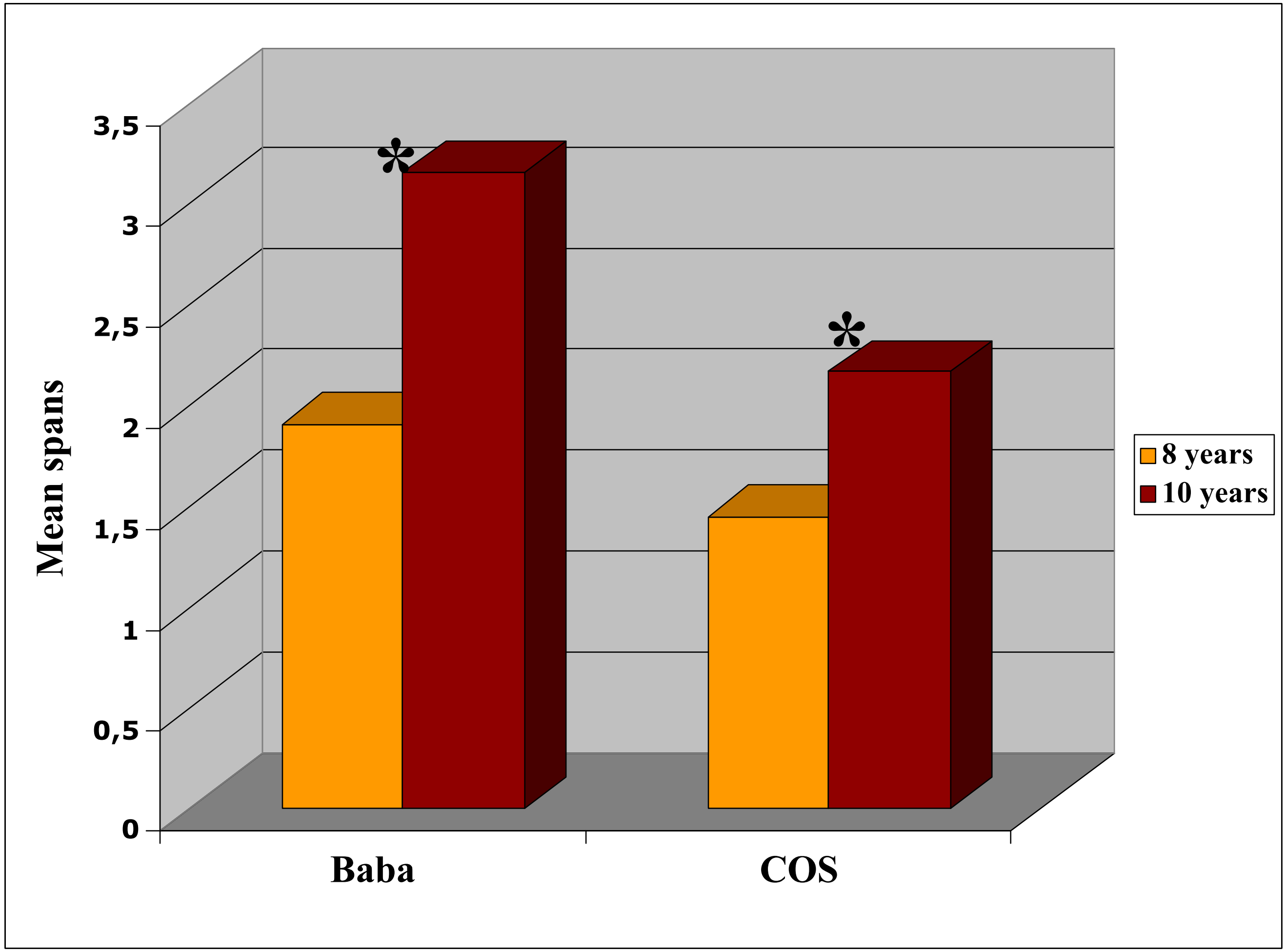
Baba: same number of syllables

Participants:

2 groups of 24 children aged 8

2 groups of 24 children aged 10

Results



Significant interaction

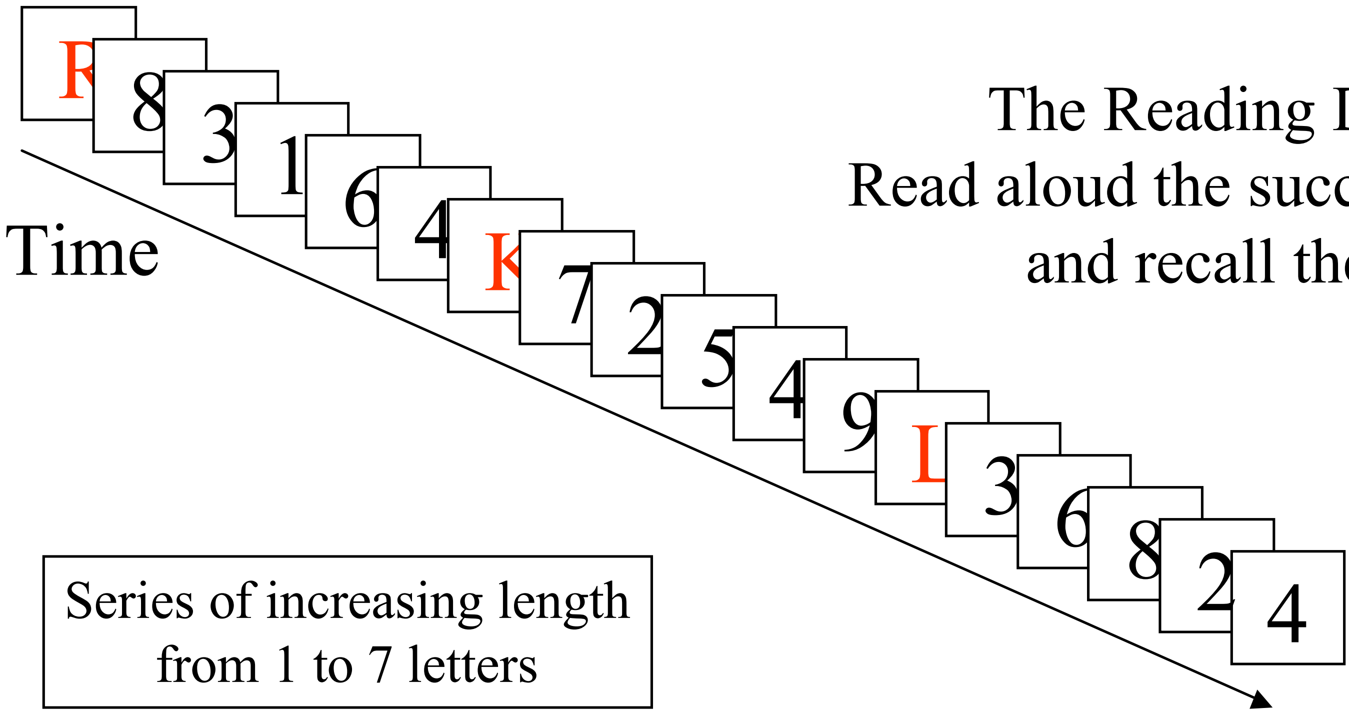
Exp. 3
Conclusions

Equating difficulty in COS leads to reduced developmental effect.

But even when duration and difficulty are equated, older children still outperform younger children.

Greater efficiency and shorter delays of retention account only for a part of the developmental increase in WM spans

Exp. 4: Do the differences persist when efficiency is equated **across individuals** ?

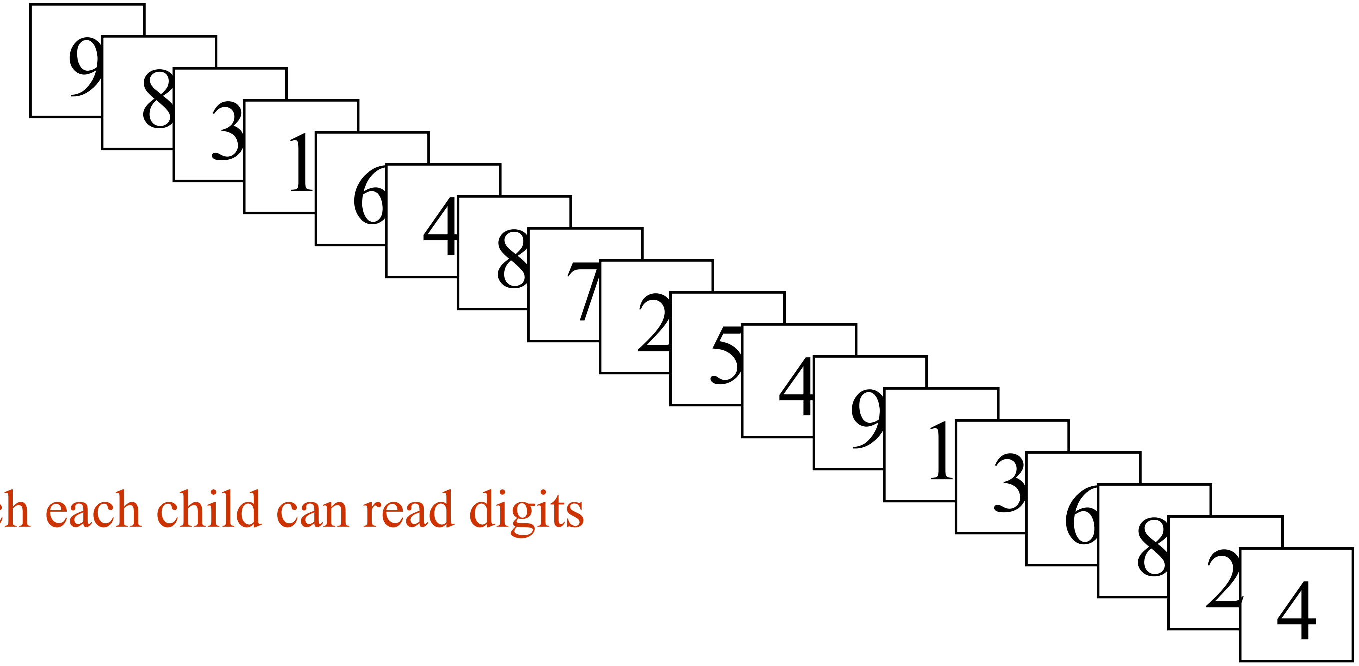


The Reading Digit task
Read aloud the successive screens and recall the letters

Series of increasing length from 1 to 7 letters

Barrouillet & Gavens, in prep.

Equating the difficulty



Maximum speed at which each child can read digits without any error.

Children performed the reading digit span task twice:

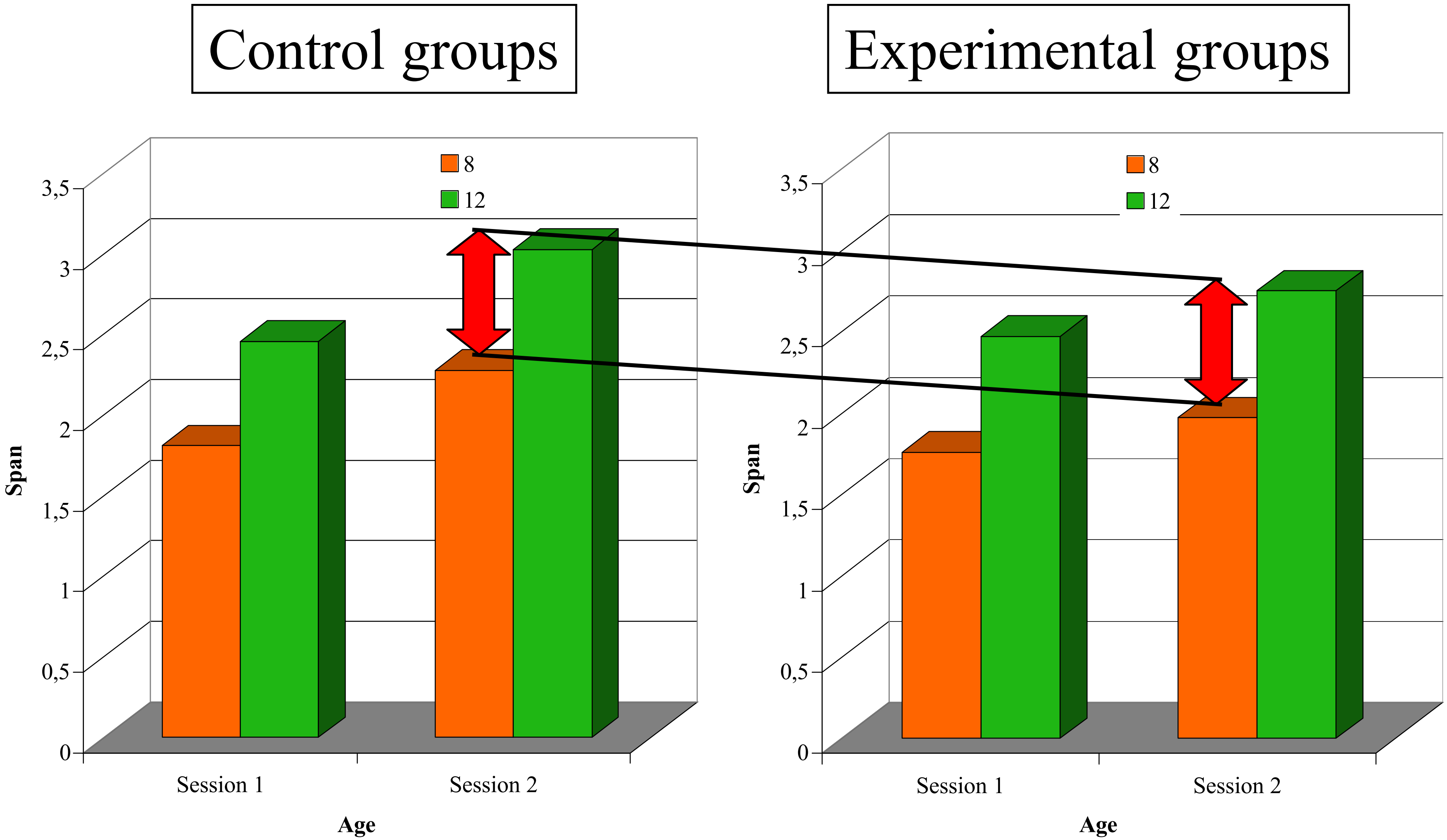
1. At the comfortable pace of 1 digit per second (6 s between two successive letters)
2. At their maximum speed during 6 s between two successive letters.

Design of Exp. 4

session	Control groups	Experimental groups
1 Reading digit span	Fixed Pace 1 digit / sec	Fixed Pace 1 digit / sec
2 Reading digit span	Fixed Pace 1 digit / sec	Adapted Pace

Children aged 8 and 10

Results


Control groups
Experimental groups
8
12
8
12
3,5
3
2,5
2
1,5
1
0,5
0
Span
Session 1
Session 2
Age
Session 1
Session 2
Age

Exp. 4
Conclusion

❖ Equating processing efficiency barely reduces developmental differences.

❖ Incidental remark: Strong training effect

❖ Thus, comparing Exp. 3 and 4 suggests that the design to equate processing efficiency leads to more or less reduction of developmental differences

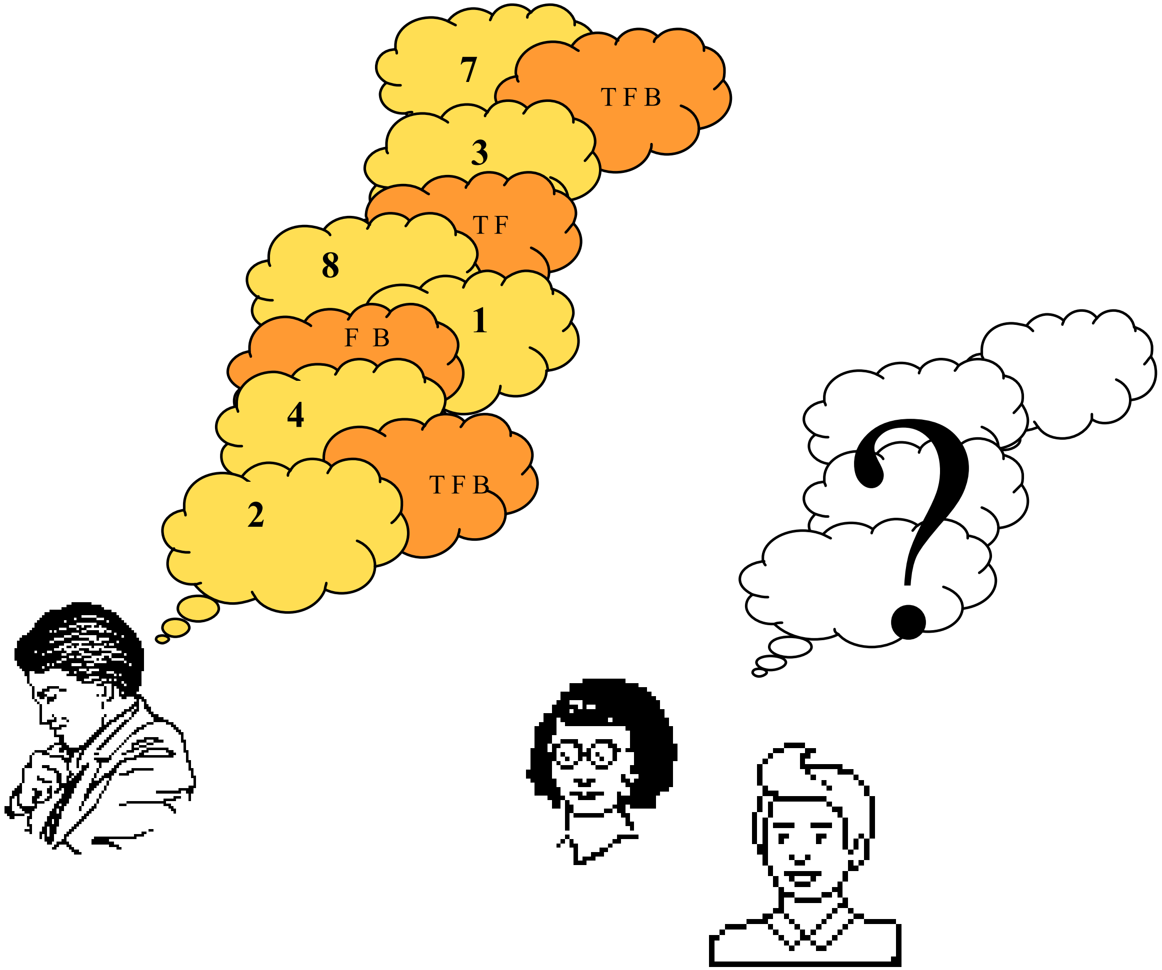
Control of delays of retention
Control of processing efficiency

Still a developmental increase in WM spans

A developmental increase in the amount of attention

The efficiency of switching

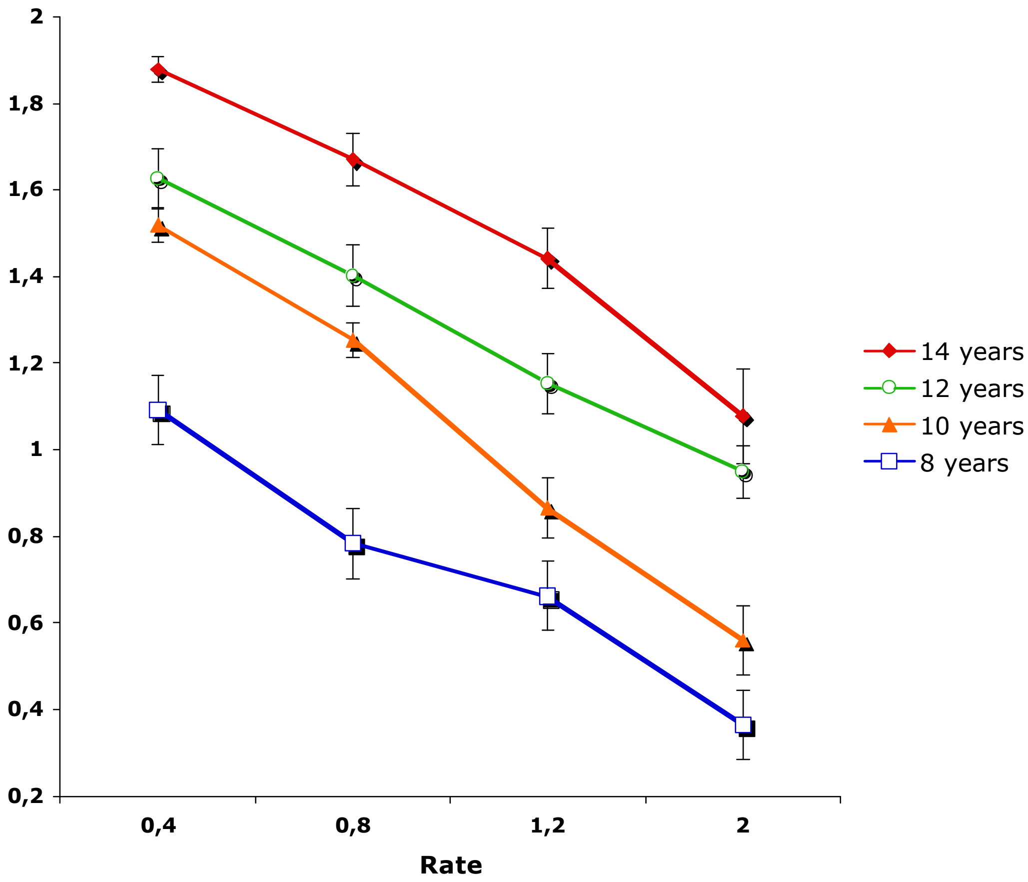
Is there a switching process in children ?



Exp. 5 : Development and switching

Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, in revision, Dev. Psy., Exp. 1

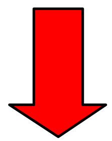
4 paces of a Reading Digit Span task



Children switch their attention from processing to storage

Age-related evolution

Less efficient (or used?) in younger children

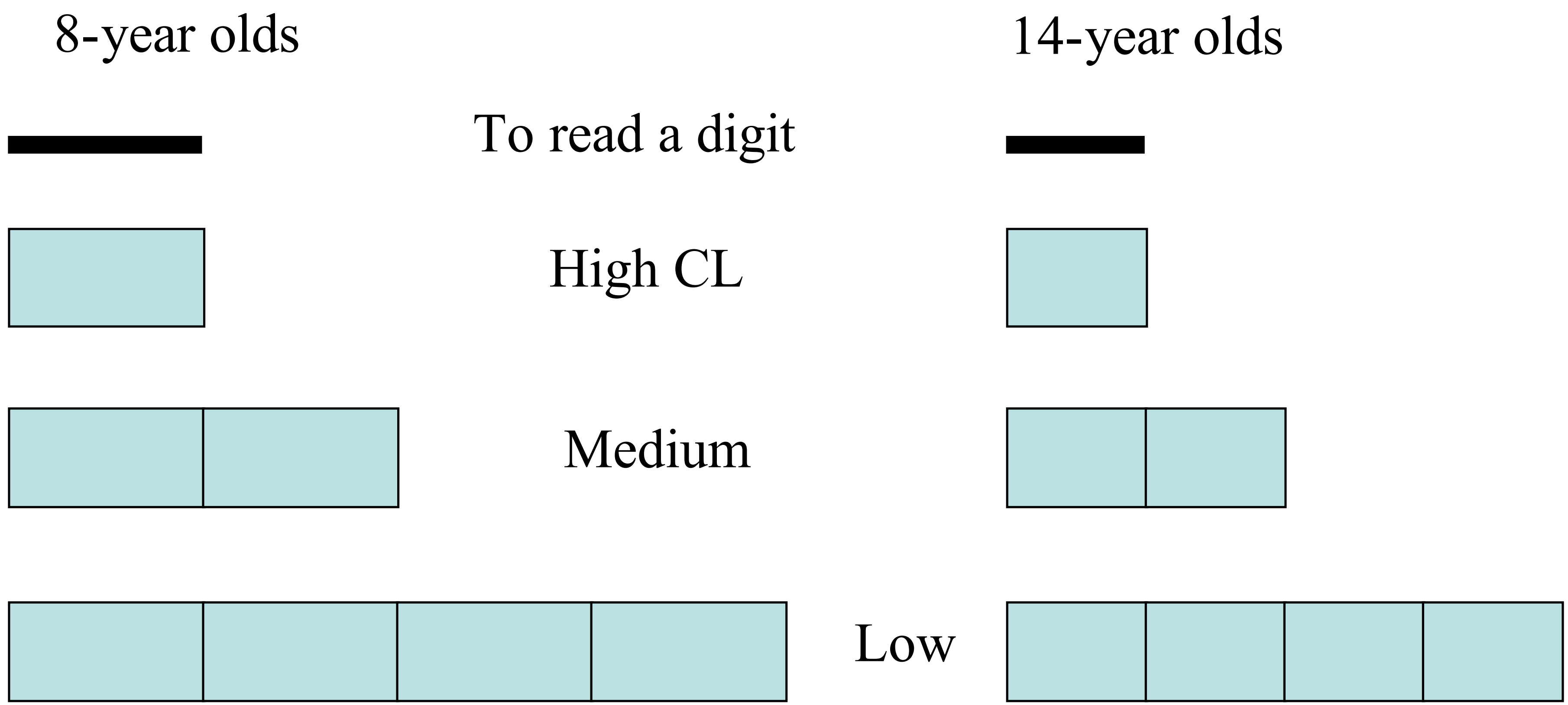


Paradoxically, older children are more affected by CL changes than younger children are.

Exp. 6 : Controlling age differences in processing speed

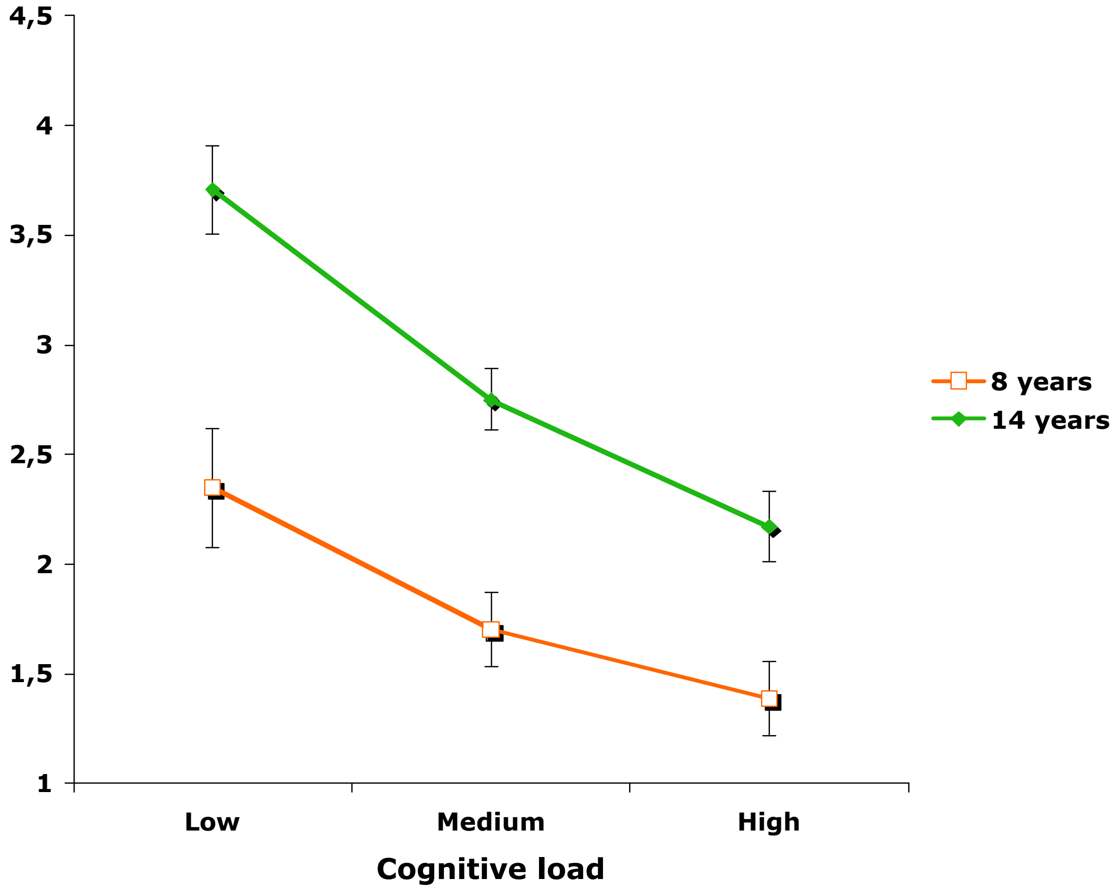
Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, in revision, Dev. Psy., Exp. 2

Reading = 25%, 50% or 100% of the inter-letter interval



Exp. 6 : Controlling age differences in processing speed

Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, in revision, Dev. Psy., Exp. 2



Although CL constant, older children still outperformed younger children

↓

Developmental increase of attention resource

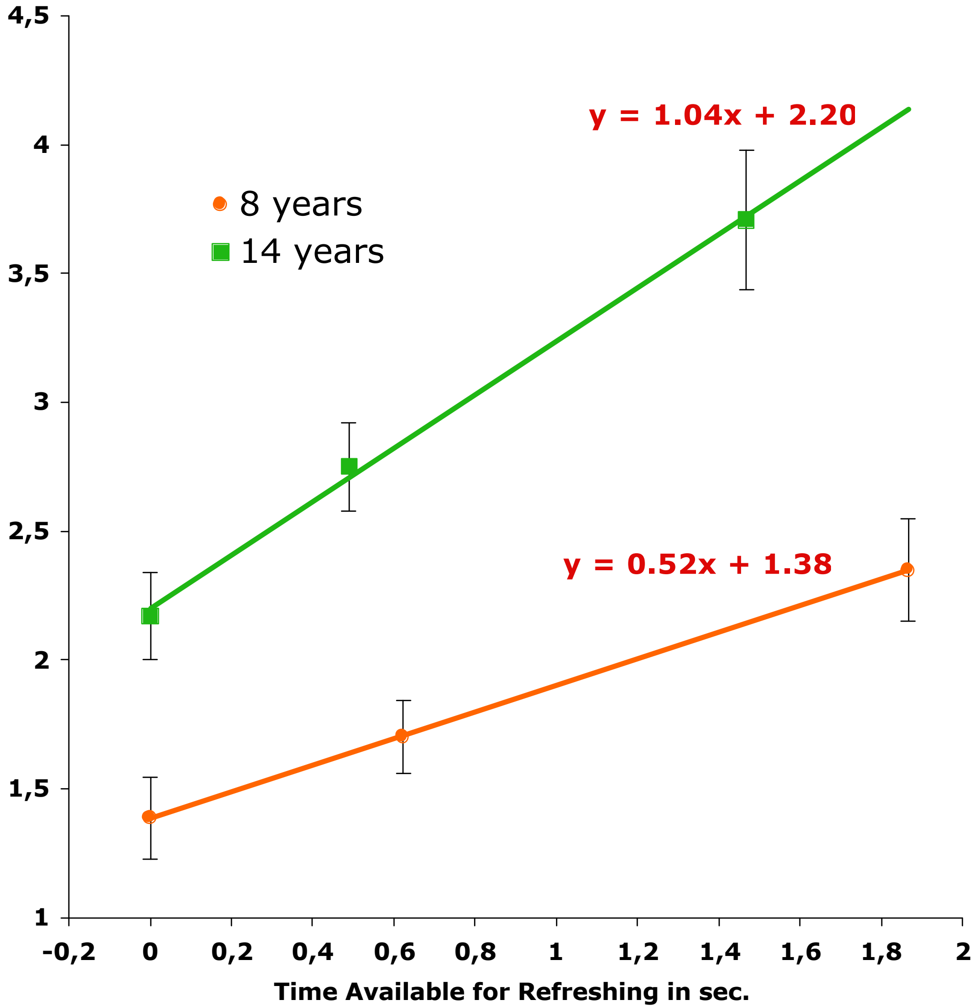
No more interaction Age x CL

↓

Processing speed differences

Exp. 6 : Increase in efficiency of refreshing

Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, in revision, Dev. Psy., Exp. 2

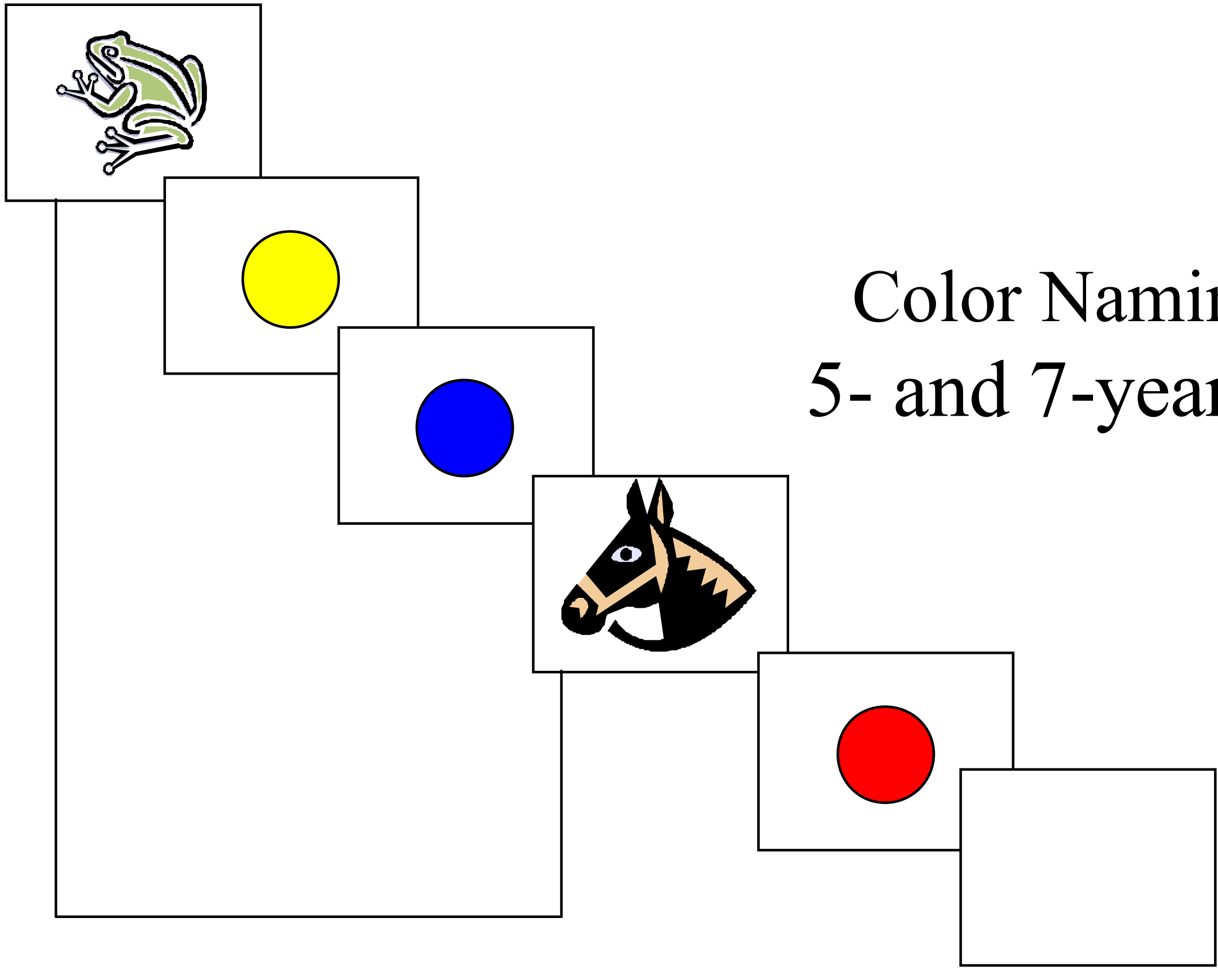


The rate of refreshing is **twice** in 14 vs 8-year-old children

Greater than the developmental increase of processing speed (1.2)

Exp. 7 : An age without refreshing ?

Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, in revision, Dev. Psy., Exp. 3

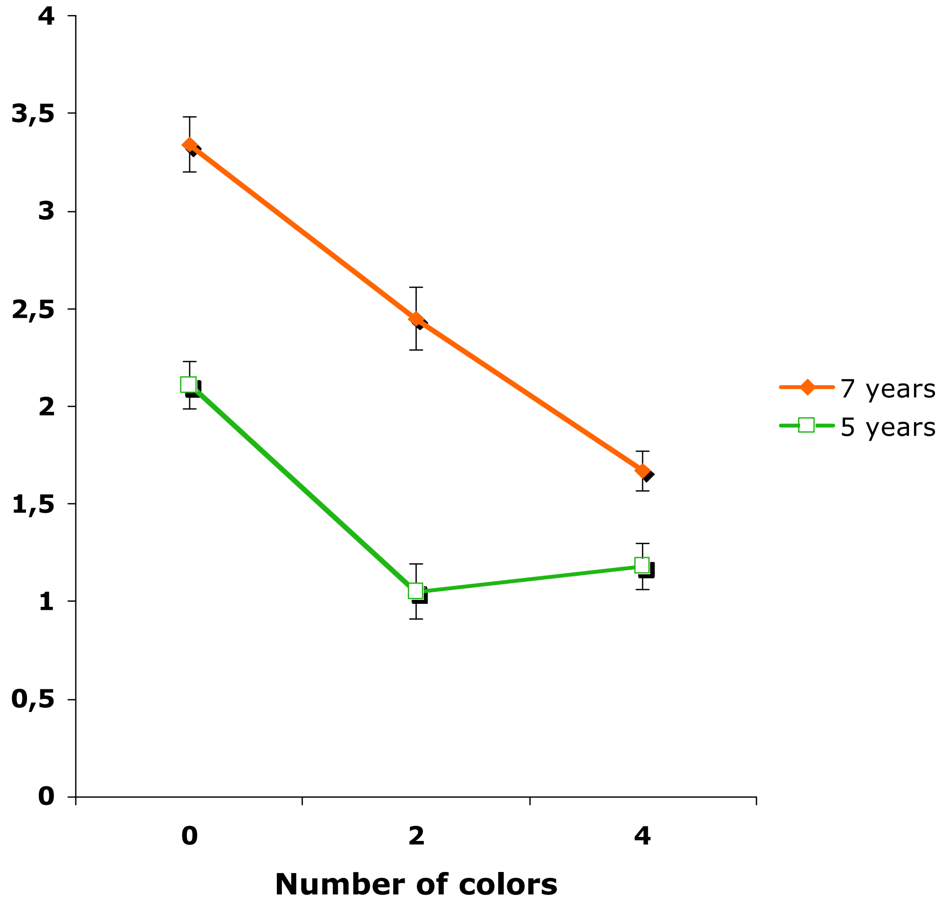


0, 2 or 4 colors

Color Naming span Task
5- and 7-year-old children

Exp. 7 : An age without refreshing ?

Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, in revision, Dev. Psy., Exp. 3



At 7,
pan decreases with the number of color

Efficient switching

At 5,
Span unaffected!

NO Switching

At both age, an intervening task affects the maintenance of items

Exp. 8 : Qualitative change ?

Camos, in prep.

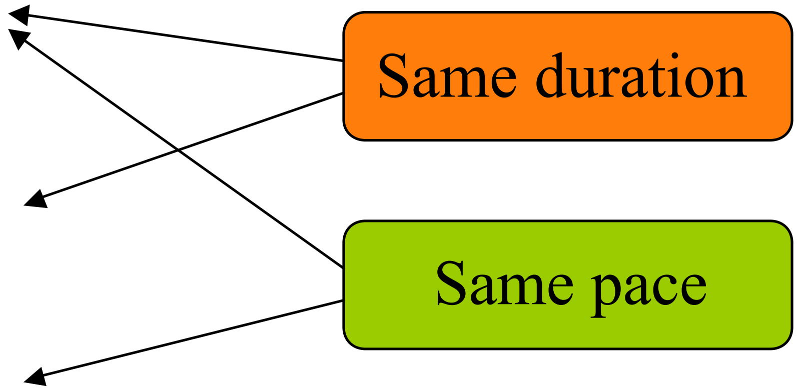
Color Naming span Task 5- and 7-year-old children

3 conditions:

1 color in 2000 ms

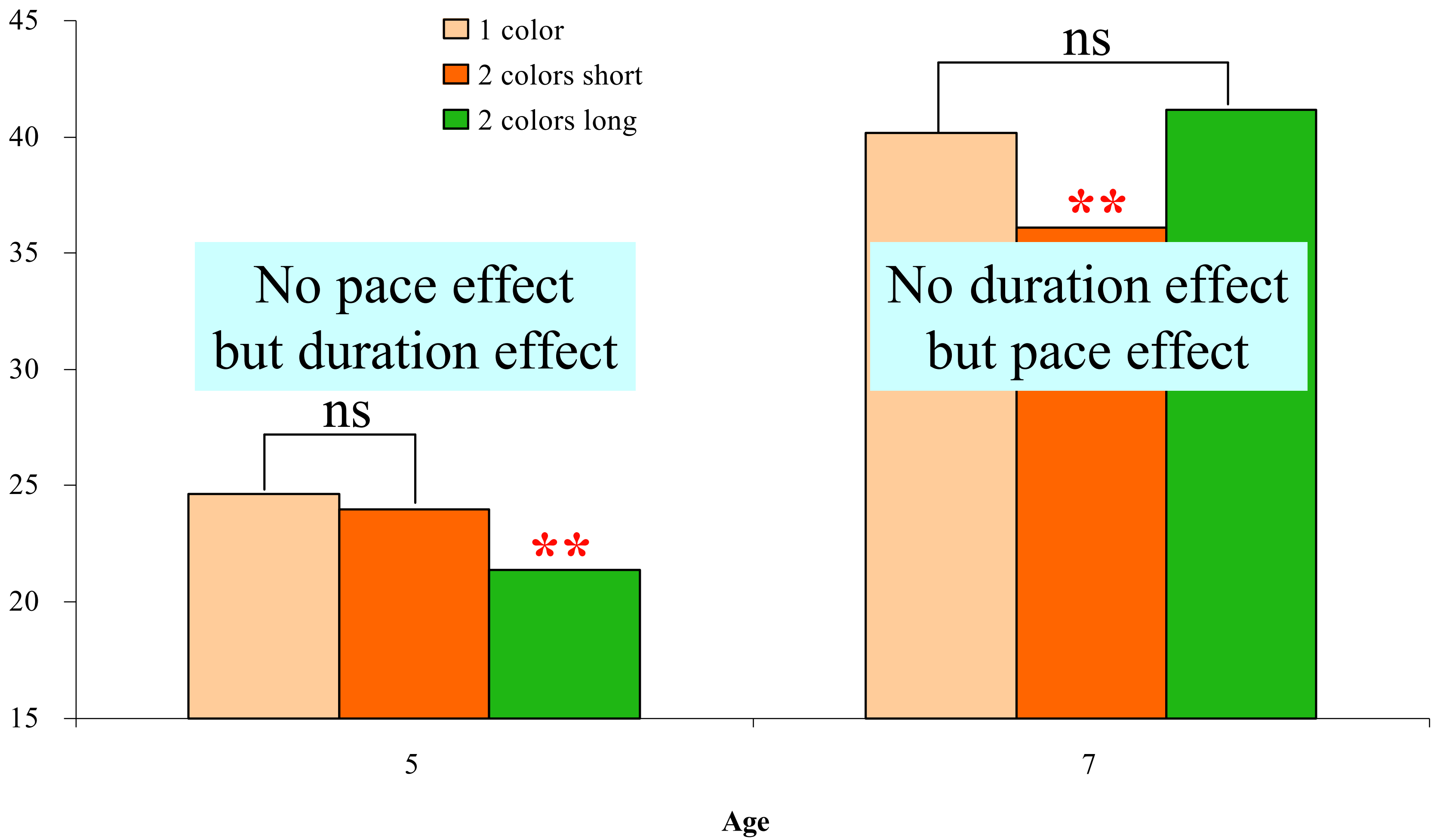
2 colors in 2000 ms

2 colors in 4000 ms



Exp. 8 : Qualitative change ?

Camos, in prep.

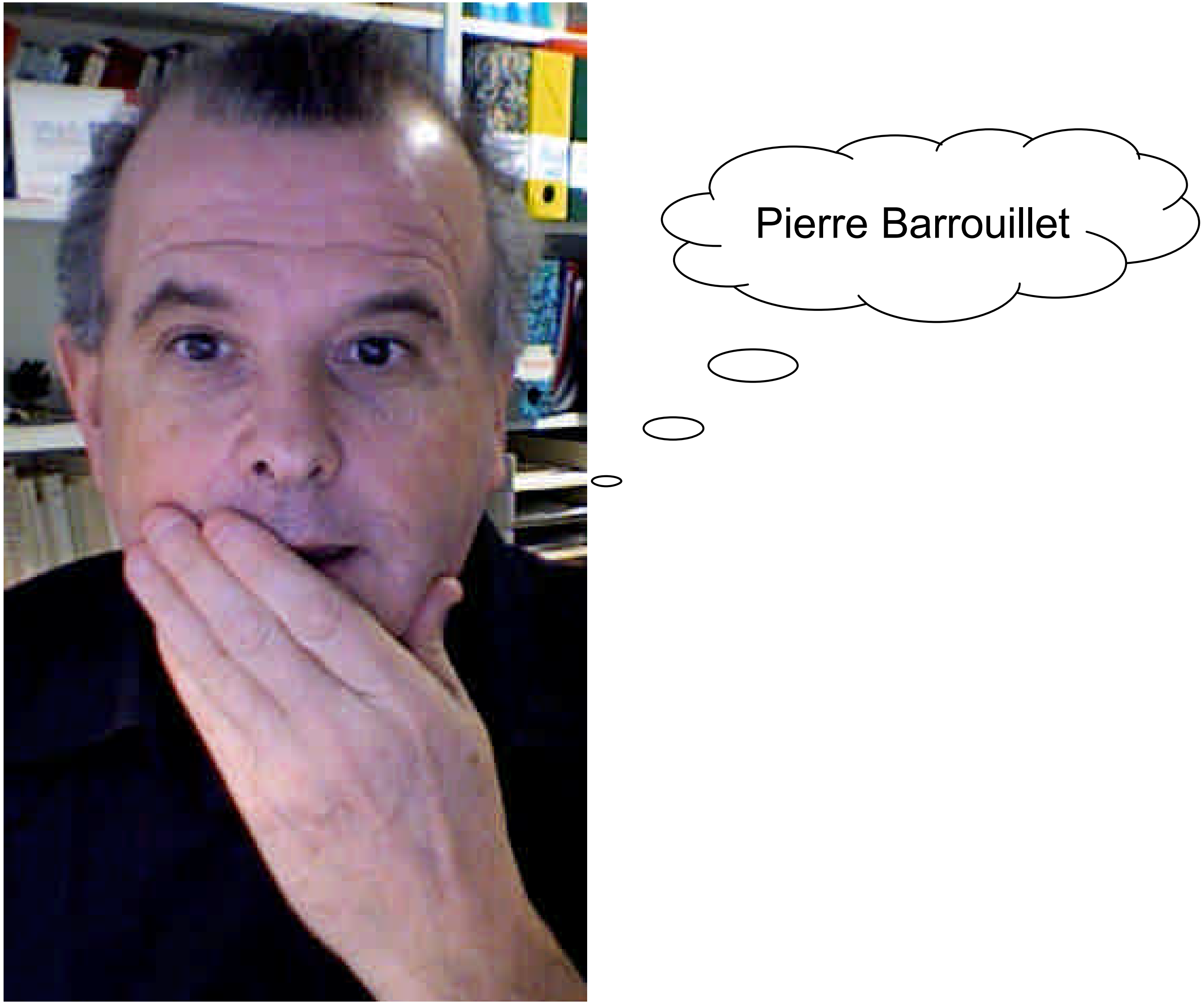


To conclude

The factors that underpin the developmental increase in Working Memory spans

- ❖ The amount of available attention
- ❖ The efficiency of refreshing
- ❖ The speed of decay…. Nelson Cowan

Pierre Barrouillet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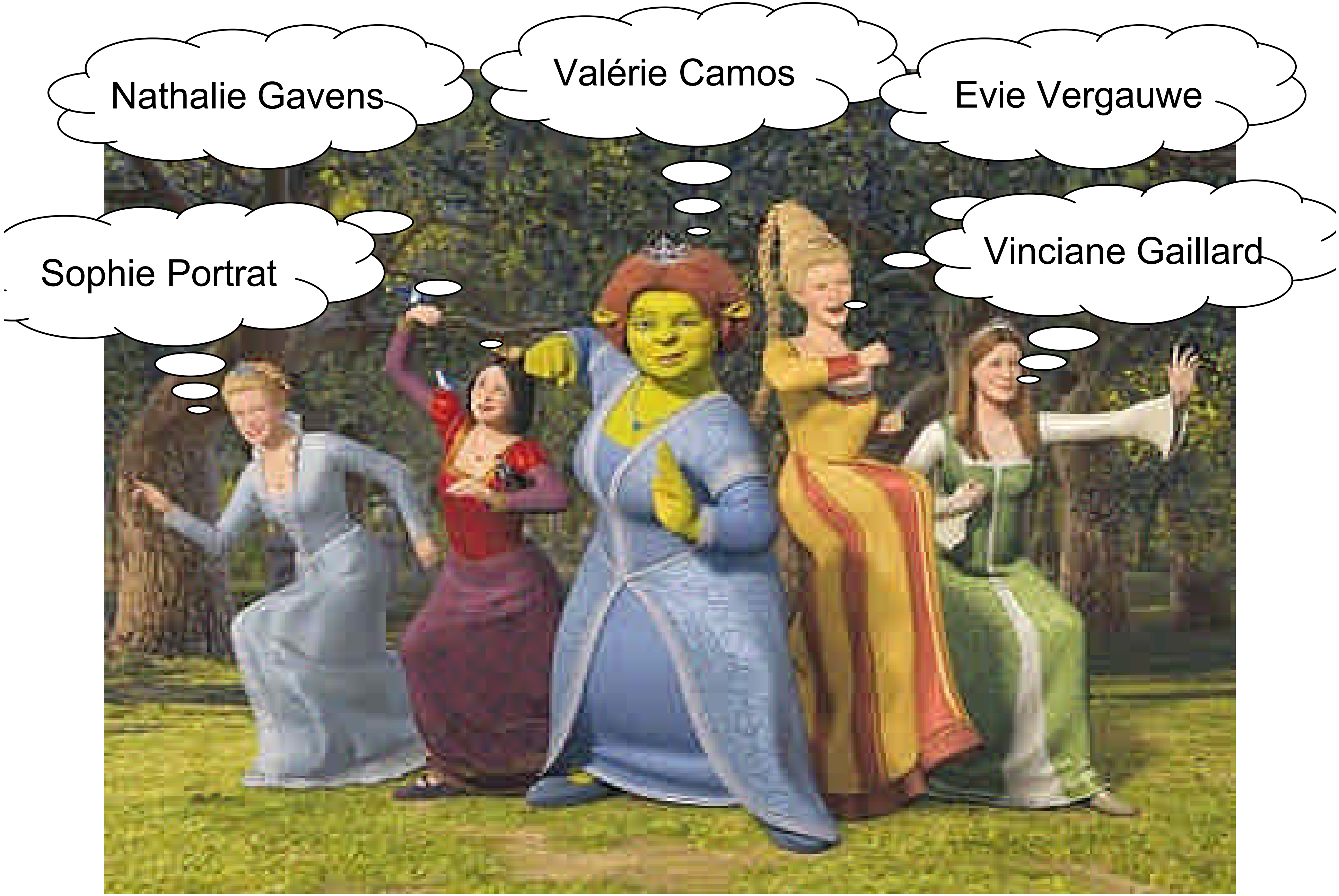
Nathalie Gavens
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Sophie Portrat
Vinciane Gaillard


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