Do you need a good working memory to learn to count?

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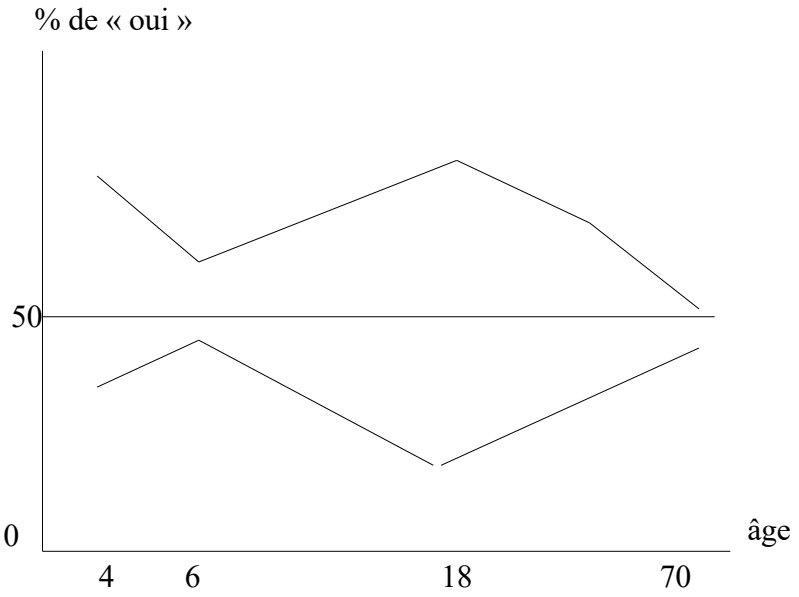
Adult data

In short...

- Hypothesis
- The BP and Ad Ce components are involved in the monitoring of the metering
- This involvement changes over the course of a person's life
- Method
- Survey of children aged 4 and 6, young and old adults.



A frequent difficulty : arithmetics

- In simple arithmetic, children with mathematical disability (MD)
  - produce more errors,
  - are slower,
  - use less mature strategies than controls
    - E.g., they use counting (3+5=4,5,6,7,8) when the others retrieve the answer from LTM

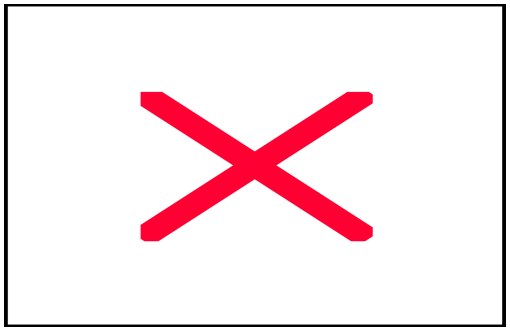
Fleischner et al., 82; Geary et al., 87, Geary et al. 90,

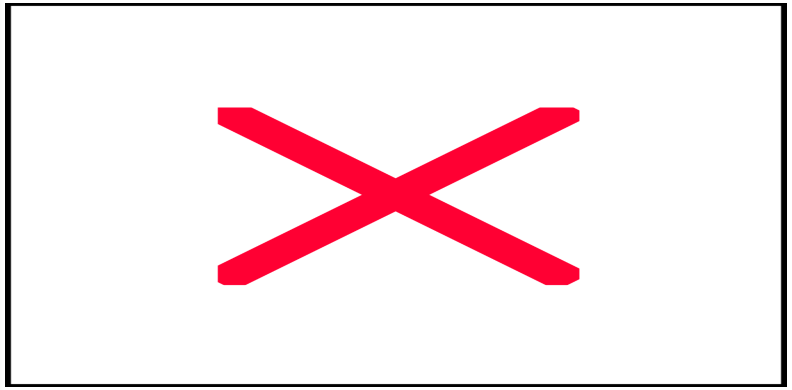
Geary's hypothesis

- Low WM capacities in MD children would prevent them to form AF, I.e., an association in LTM between the problem and the answer
- Condition for forming an AF: co-activation of both representations in WM
- Conditions of this co-activation
  - Addition strategy
    - 5+3=1,2,3,4,5,6,7,8
    - 5+3=6,7,8
  - WM capacities

WM capacities in MD

- Lower forward digit span
  - Geary, Brown & Samaranayake (1991)
  - Hitch & McAuley (1991)





WM in learning to add ?

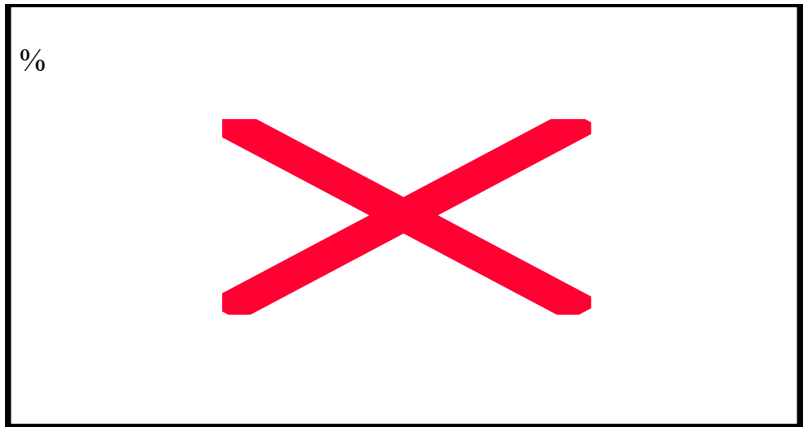
Goal:

- Evaluate the predicting power of WM capacities (PL & CE) on addition learning
- Compare the predicting power of WM and processing speed

Noël, Seron & Trovarelly (2004)

- population: 25 first-grade children (6;7 y.o.)
- November: cognitive predictors
  - PL: digit span, short-word span, long-word span, non-word repetition
  - CE: listening span
  - Processing speed: code subtest (WISC)
- March: calculation
  - 40 one-digit additions
    - algorithm :
      - Counting all: 2 + 8 = 1,2,3,4,5,6,7,8,9,10
      - Counting on: 2 + 8 = 3,4,5,6,7,8,9,10
      - Counting min: 2 + 8 = 9,10
      - Retrieval: 2 + 8 = 10
    - support : finger - verbal - mental

Subgroups with low vs. high PL capacities



interpretation

- Weak WM capacities => less accurate

  => monitoring the counting string (cfr adult studies: Healy & Nairne, 85; Logie & Baddeley, 87):

  => monitoring the number of counting steps
- Weak WM capacities => concrete support needed to monitor the counting steps

  => finger counting
- Weak WM capacities => less mature counting strategies
  - Why ? Immature counting string ?

WM in learning to count ?

- PL capacities have been shown to predict vocabulary acquisition (Gathercole)
- What about the number words ?
- Particularities
  - Number words must be recited in a specific order
  - The counting string needs to be elaborated
    - *Unbreakable list*
    - *Breakable chain (start counting from n≠1)*
    - *Numerable chain (counts number words)*
    - *Bidirectional chain (recite in both directions)*

Predictions

- Phonological loop capacities are related to
  - Development of the number vocabulary
  - Development of the counting string (order)
- Central executive capacities are related to
  - The level of elaboration of the counting string
  - Ability to use counting to solve additions

Method

- Population
  - 38 4 y.o. & 42 5 y.o.
- Evaluation of
  - Counting level
  - Calculation abilities
  - WM capacities
  - Vocabulary
  - Non-verbal reasoning

Numerical measures

- Counting measures
  - Count as far as you can (x3)
  - Number fluency
  - Number decision task (*Lundi, juillet, huitante, neufze)*
- Level of elaboration of the counting string
  - Counting from /up to a number
  - Counting x steps from a given number
  - Counting backwards
- Calculation
  - simple additions with the first addend drawn as a collection of items (n=10)

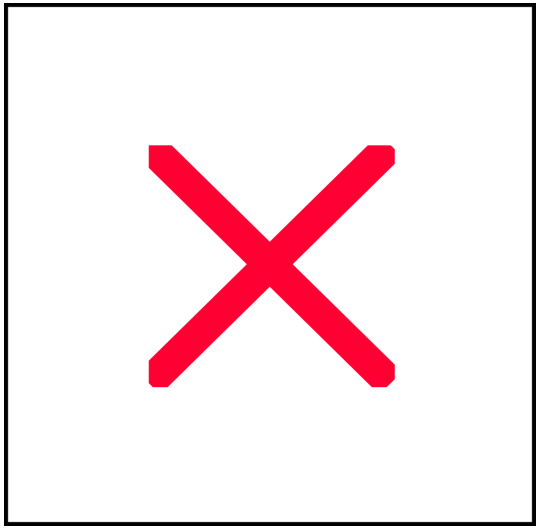
WM measures

- Slave systems: storage capacities
  - 2 short word span, nonword repetition
  - Corsi span
- Decay sensitivity
  - Nonword repetition after 5 and 10 s.
- Central executive
  - Complex span
    - Short-word span in the reverse order
    - Short-word span with a categorical restitution (animals/food)
  - Day / night
- Naming speed (speed of access to LTM)

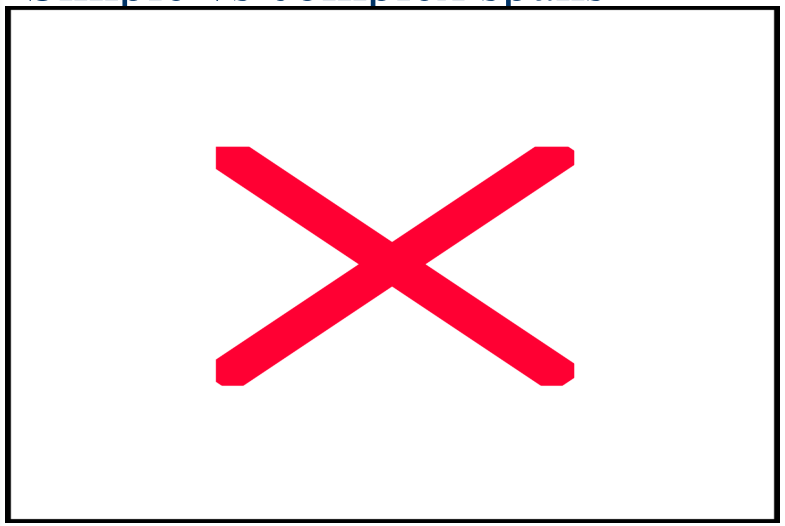
Other measures

- Vocabulary: Picture naming test
- Non-verbal reasoning test: Raven colour matrices

non-numerical tasks

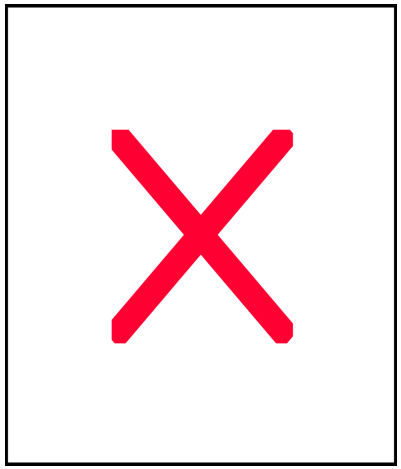


Simple vs complex spans

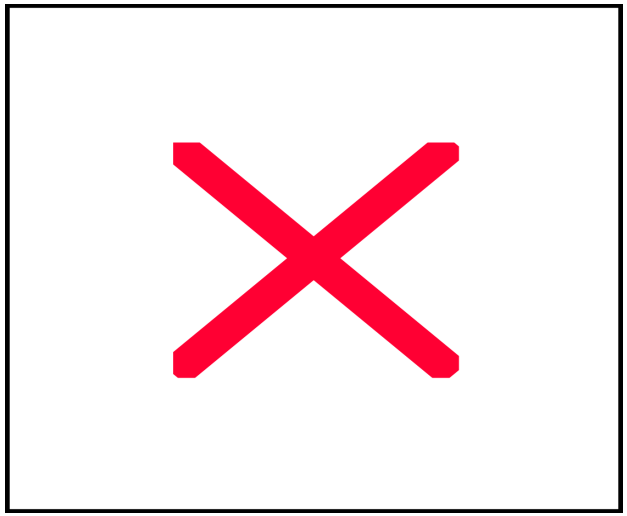


Decay with a delay

- Effect of
- Grade (.0001)
- Delay (.0001)
- Grade * delay (.02)



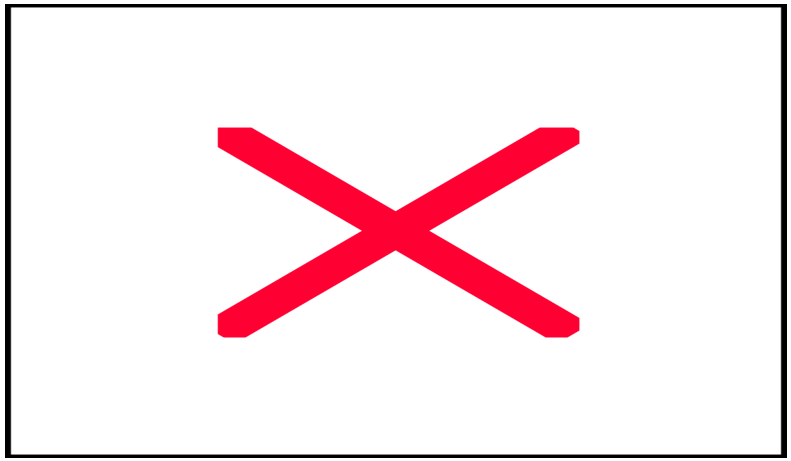
Correlations between the non-numeric variables



Sélection of 4 measures

- Phonological loop measurement
- 3 single verbal spans + 10s repetition
- Measurement of the visual-spatial notebook: Corsi
- Central Administrator Action
- Average of the category and span
- Measurement of access speed: v. de déno
- Inhibition measurement: average of the z score on err (interference - control) and TR (interference - control)

Tâches numériques



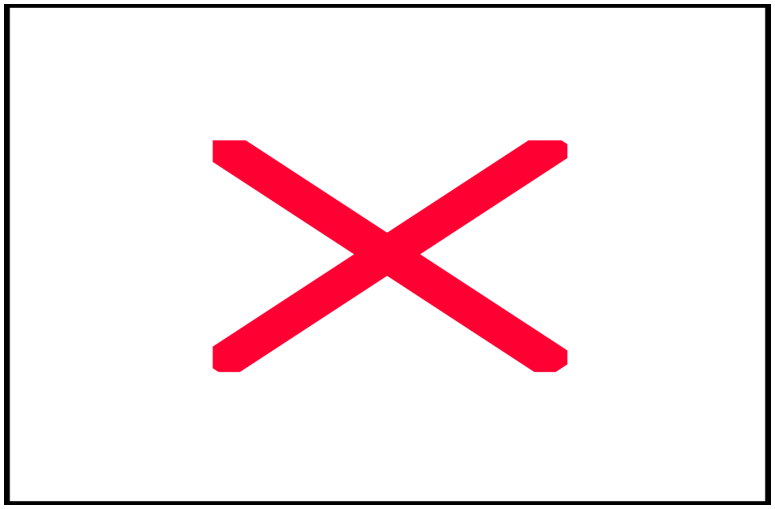
RC in additions

- Item Analysis
- VD: % correct answers by sex x class
- VI: correct sum, second term, double or not, class, sex
- Stepwise regression: (1) class, (2) second term size, (3) double: 81.1%

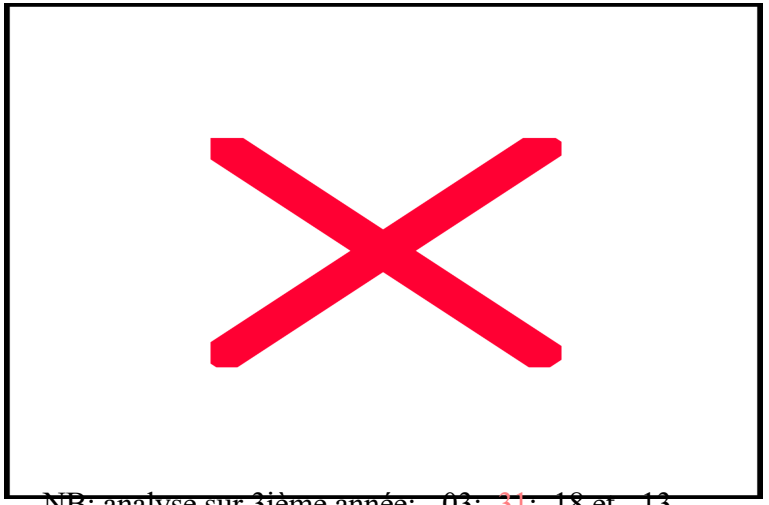
WM and counting

- Correlations between numerical and non-numerical variables

Pearson correlations



Correlations partielles / age et matrice

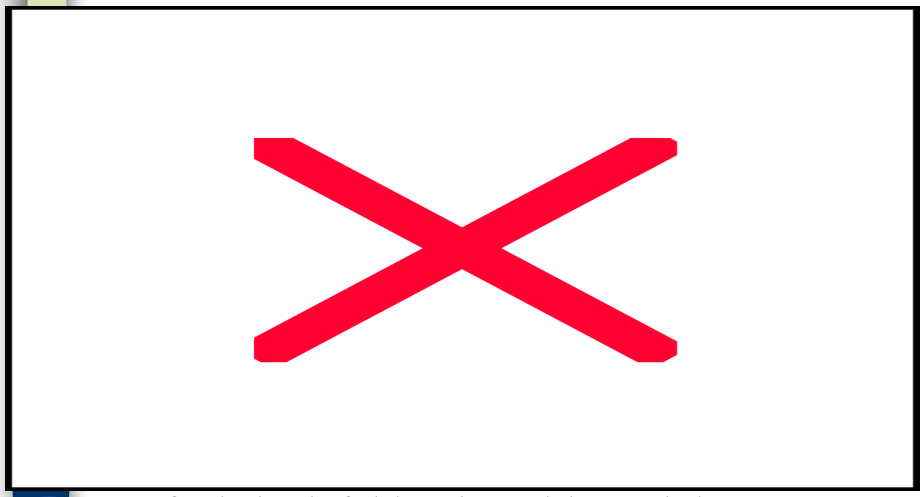


NB: analyse sur 3ième année: -.03; .31; .18 et -.13

- Corsi: ns
- Naming speed:Prédicteur plus faible
- BP & Ad ce: bons prédicteurs; si analyse stepwise: 1! Facteur sort, l 'autre n 'ajoute plus rien (r(BP-AC)=.674)

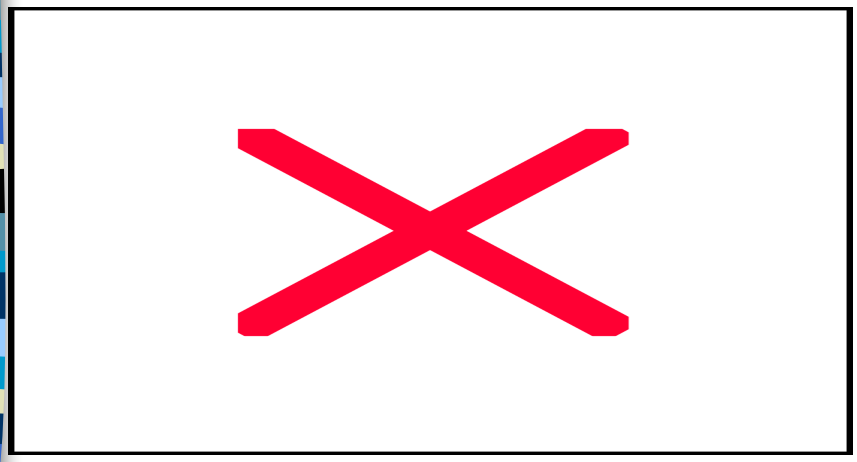
- Split of the population in two subgroups
  - Those with lower memory spans than expected for their age
  - Those with higher memory spans than expected for their age
- No significant differences when groups are based on the VSSP measure
- Significant differences when groups are based on the PL or the CE measures

Phonological loop

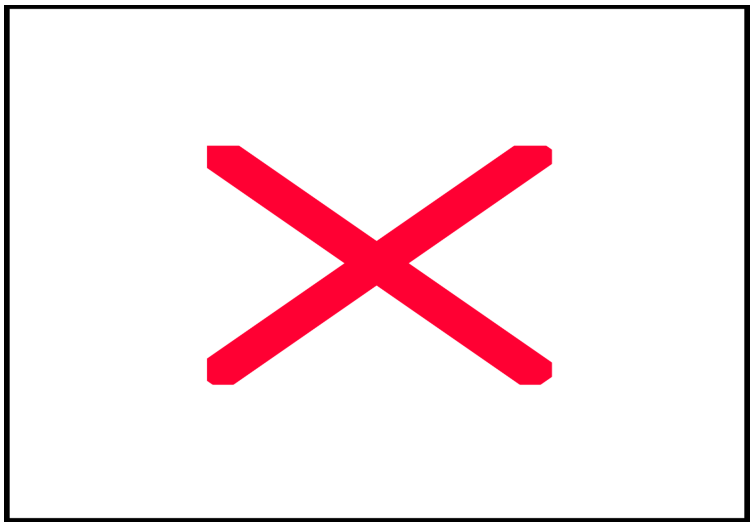


≠ for the level of elaboration and the vocabulary

Central executive



Storage & processing



Low WM: a way to MD ?

- Weak WM capacities =>
  - Smaller number vocabulary
  - Less extended number string
  - Lower level of elaboration of the counting string
  - Less mature counting strategies in addition
  - Weaker abilities to monitor counting for calculation
  - More calculation errors
  - Use of external support
  - Poor conditions for establishing an association in LTM between a problem and the correct answer

Perspectives futures

- Correlative studies: how to go further?
- Measuring the deleterious effects of an overload of the MdeT:
- visuospatial vs. verbal material to be memorized during the counting or calculation task
- Unattended speech or images during the task

WM in learning to add ?

- Geary: AF needs the coactivation of the problem & the answer in WM
- Couting speed

  5+3=4,5,6,7,8

  5+3=4...5...6...7...8
- Couting strategy

  5+3=1,2,3,4,5,6,7,8

  5+3=6,7,8
- WM capacities

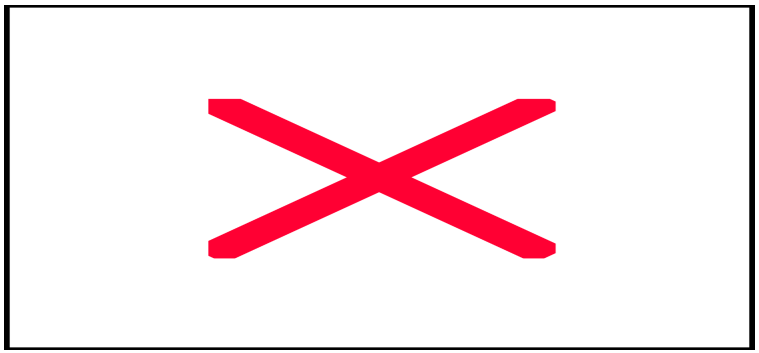
- The repeated use of counting to solve a problem does not lead to the constitution of an AF (problem-answer in LTM)
  - Thevenot, Barrouillet & Fayol (2001)
    - Add: 39/16 /55=sum?/ 16 (= n1 or n2 ?)
    - Compare: 39/16/25 = between 39&16 ?/16
    - Better recognition of 16 after compare than add

Hecht, Torgesen et al. (2001)

- Follow-up of children from kindergarten to 11 y;o;
- Kindergarten: evaluation of phonological capacities
  - Phonological memory tasks
    - Digit span, memory for sentences, listening span
  - Phonological analysis and synthesis
    - Phoneme elision, phoneme segmentation, sound categorisation, blending phonemes into words, blending phonemes into nonwords
  - Rate of access
    - Naming digits, letters
- General tests of reading and computational skills

Hecht, Torgesen et al. (2001): results

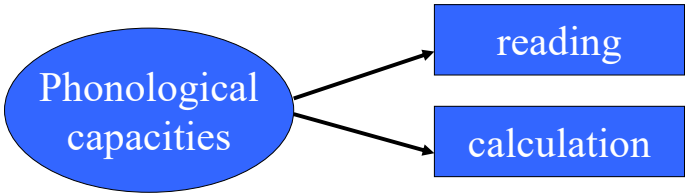
- Correlations with math performance



Role of the phonological capacities in the correlation between calculation and reading?

- corr (calcul - reading) .60 - .64
- corr (calcul-reading) / intelligence .41 - .54
- corr (calcul-reading) / intelligence & WM .33 - .35
- corr (calcul-reading) / intelligence & 3 phono measures .00 - .01

=> phonological capacities influence both the development in math and in reading



But by which mechanism ?

Mean and *p* value

Processing cost