Neuropsychological approaches to dyscalculia interventions

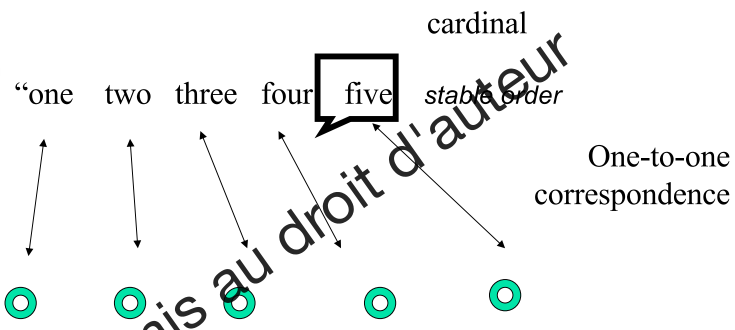
Finland, 2006

Marie-Pascale Noël

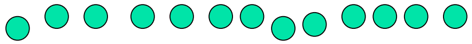
diagnosis

- Many ways top be behind in math
- Need of a good comprehensive battery
  - Counting: numerical chain,
  - dot counting (including understanding of counting principles)
  - Magnitude representation (collections, symbols)
  - Arithmetic: addition, subtraction, multiplication, divisions, simple facts (strategies used, time to answer), complex calculation (written algorithms)
  - Numerical systems: transcoding
  - Base-10 representation
  - Fractions, decimals, measures ...
  - geometry

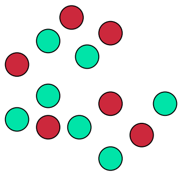
(dot) counting



<u>2 types of errors</u>:
- counting errors
- marking errors: difficulties in distinguishing between the already-counted and the to-be-counted objects
-error of coordination between the oral counting and the pointing (the more frequent, Fuson, 88)



- Marking is more difficult when
  - The collection is big
  - The objects are located randomly
  - The stimuli are all the same



- Pointing
- Oral counting
- The coordination of these two activities
  - Time for pointing, for oral counting only, for dot counting
  - 6 y.o.; 8 y.o. and adults
  - Time for dot counting < to the slower component of the two

=> not two independent activites plus the cost for coordination

=> Whole procedure integrated

=> Coordination errors reflect the development of this procedure

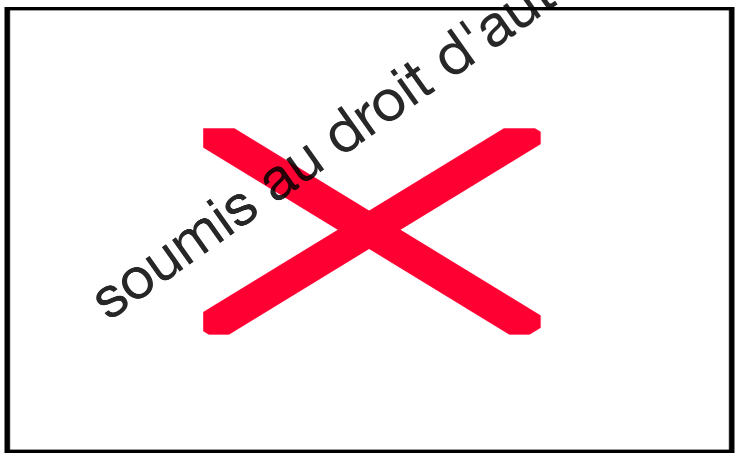
(Camos, Barouillet et Fayol, 2001).

Training the oral counting and the pointing alone would decrease coordination errors in dot counting ?

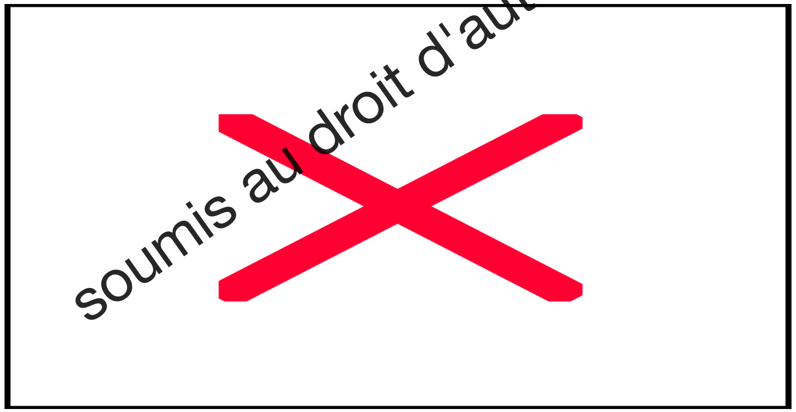
Training (10 sessions)

- Thao: 6 y.o., many errors in oral counting and dot counting (mainly coordination errors)

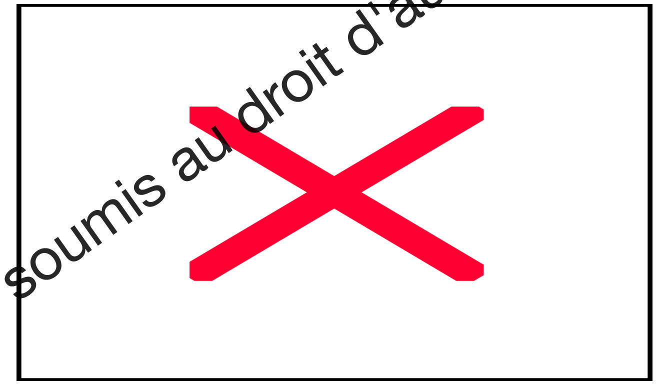
Baseline oral counting



Baseline pointing



Baseline dot counting



Numerical chain

- Counting up to 20
- Counting and adding a gesture between the number words (clapping your hands, clapping you hands and feet)
- Counting in alternance with the therapist

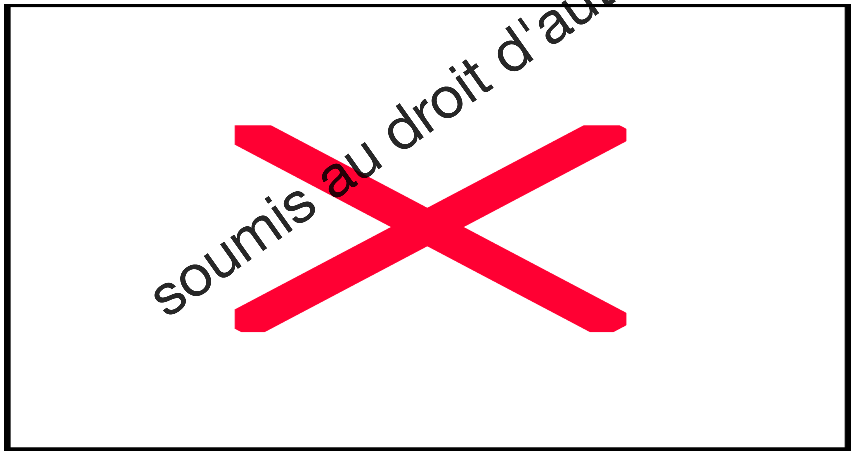
Rythm

- Following a regular rythm together with the therapist (slow, fast)
- Following a regular rythm, starting with the therapist and continuing alone

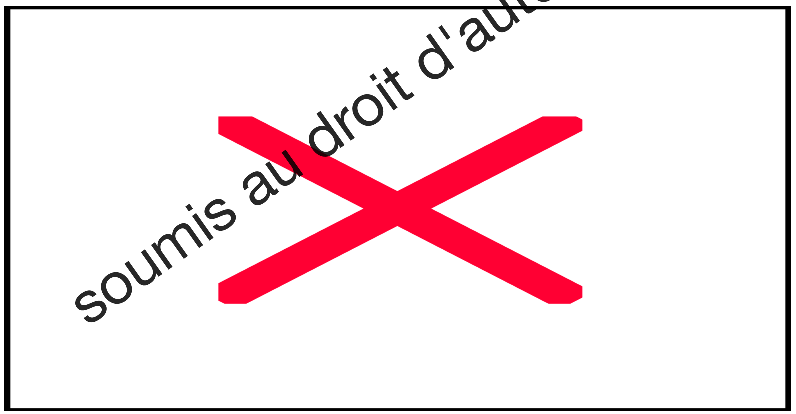
Pointing

- Pointing each dot after putting some colour on your finger; using lighter colour
- Pointing to linear patterns (less and less spaced),
- Pointing to linear pattern arranged in rectangle
- Pointing to dot arrays put in cercle
- Pointing to dot arrays put randomly

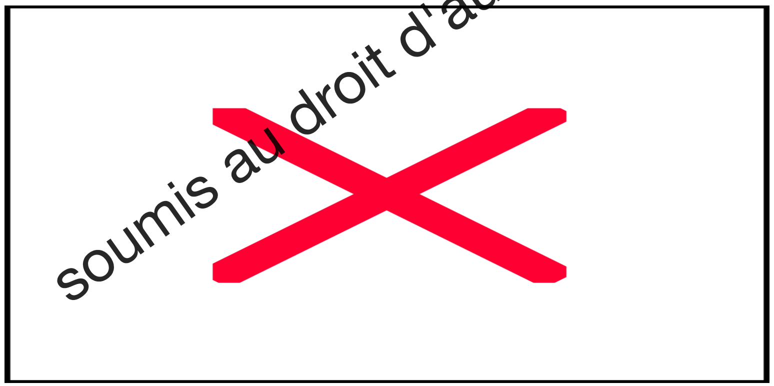
Oral counting



Baseline pointing



Baseline dot counting



Simple arithmetic

"Simple arithmetic"

- 1-digit operations
- DC children are slow to answer, use immature strategies and few retrieval of the answer from LTM
- Acquired dyscalculia
  - Drill training: efficient but mainly of the trained problems (Delazer, Semenza & Denes, 1994)
  - Strategical training: efficient and has an impact on both trained and untrained problems (Girelli, Bartha & Delazer, 2002)

"Simple arithmetic"

- In developmental dyscalculia
  - Drill on additions for 3 months increases speed and accuracy, except for the slowest children (Goldman, Pellegrino & Mertz, 88)
  - Drill for multiplication in a teenager DC: no effect (Howell, Sidorenko & Jurika, 1987)
- ≠ between addition & multiplication ?
  - Multiplication might be more memory-based (verbal associations: Dehaene),
  - addition might be more strategy-based: priming of the operation sign (Roussel & al. 2002)

"Simple arithmetic"

- Hypotheses
  - Drill might be more efficient than strategies for multiplication
  - Strategical training might be more efficient for addition than multiplication

Simple arithmetic: drill-based training

- 3x4=12 “read”
- Repeat
- 5x6=30: read
- Repeat
- 3 x 4 = ? give the answer
- 5 x 6 = ? give the answer
- 3 x ? = 12 give the answer
- 5 x ? = 30 give the answer
- ? X 4 = 12 give the answer
- ? X 6 = 30 give the answer

- problems 1&2; 3&2, 3&1, 4&3, 4&2, 4&1, 5&4, 5&3, 5&2, 5&1 => each problem is seen in four runs

Simple arithmetic: drill-based

- Drill-based games (with the trained items only)
- “war”:
  - Each has a pile of cards with a problem
  - Each one turns on a card on the table, the one with the bigger result takes the two cards
- “snakes and ladders”
  - Game platform with problems written on the squares; throw the die; progress if you can give the answer to the problem or go back if you can not

Simple arithmetic: strategy-based training: addition

- Oral counting:
  - count as far as you can, from a number, to a number, from and to, x steps from a number
- Understanding the meaning of the operation
  - Story <-> mathematical formalism
- Developing more mature strategies
  - From counting all to counting on:
    - adding 2 collections of dots printed on cards,
    - increasing the delay between the 2 cards,
    - replacing the first collection by an Arabic digits,
    - replacing the two collections by Arabic digits

Simple arithmetic: strategy-based training for addition

- From counting on to counting min:
  - presenting problems with big ≠ between the addends (a card with 8 on one side, 3 on the other),
  - experiencing counting from one side or the other, which is faster ?
  - looking at the 2 sides and then deciding where to start
- Decompositions
  - The token game: tokens with one white face and one red face; take n tokens, throw them on the table: count the red and the white faces, see how many ≠ decompositions are possible
  - A card with canonical dot pattern: ask the child to decompose the collection, formalize it: 8 = 2+6 = 4+4, ...
  - Given a problem (8 + 3): see what is the easiest way to decompose it

Simple arithmetic: strategy-based training for multiplication

- Story <=> mathematical symbolism
  - I do to the store and by 4 apples
  - I go again to the store and buy 4 other apples
  - I go once more to the store and buy 4 apples
  - Three times to the store buying sets of 4 apples
  - 3 x $\boxed{4}$
- Commutativity
- Decomposition: 7 x6 = 6,6,6,6,6,6,6 or (6,6,6,6) and (6,6,6) which is (4x6) + (3x)
- In the Pythagore table, looking at the links between the different tables
  - Table of 5 and table of 10
  - Table of 2 and table of 4 and table of 8
  - Table of 3 and of 6

- Trained items in addition
  - Bloc 1: 2+3, 5+9, 8+2, 4+7, 6+8
  - Block 2: 3+4, 2+6, 9+3, 6+5, 7+9
  - Block 3: 5+2, 6+3, 4+8, 7+6
- Trained items in multiplication
  - Block 1: 3x4, 5x6, 2x8, 9x3, 7x6
  - Block 2: 3x2, 8x4, 2x5, 6x3, 7x9
  - Block 3: 6x2, 9x5, 4x7, 8x9
- 5 sessions (30')

"Simple arithmetic"

- Baseline (for addition)
  - Production task:
    - 5 + 9 = ? Or with the operation sign primed (150 ms)
    - 14 - 5 = ?
  - Production under temporal constraint
    - 5 + 9 = ? (max 2000 ms), 5 trained items, 5 untrained, 10 times each
  - Number matching task

5 9	5 ?
150 ms	9 ?
	14 ?
	13 ?

Simple arithmetic: drill addition

- Sandrine, 12 y.o, 6 grades, > 2 years behind
  - Production task:
    - 5 + 9 = ?
      - Faster after training but only for the trained items (1860-1462 ms: 392 ms, 2117-1996 ms: 121 ms)
    - 14 - 5 = ?
      - No ≠
  - Production under temporal constraint
    - 5 + 9 = ? (max 2000 ms),
      - More correct answer for trained items (15 vs 25/25)
      - No ≠ for untrained items (13 vs. 14/25)
  - Number matching task
    - 5 9 14 ?
      - Sum vs. Neutral foils: -219 ms before training and -1 ms after
- *Specific effect on the trained items, tendency to show fast and automatic activation of these sums*

Simple arithmetic: addition strategies

- Miguel: 9 y.o., only in grade 2, 1 year behind classmates
  - Production task:
    - 4 + 5 = ?
      - Faster after training (8019 ms vs. 6195 ms: 1824 ms)
    - 9 - 5 = ?
      - No effect
  - Production under temporal constraint
    - 4 + 5 = ? (max 2000 ms),
      - No effect
  - Number matching task
    - 4 5 9 ?
      - Difference between sum and neutral foils= 270 ms pre-training and 997 ms post-training
- *Global effect only in speed for solving additions*

Simple arithmetic: multipl drill

- Diane: 12 y.o., 6 grade, > 2 years behind
  - Production task:
    - 5 x 9 = ?
      - Faster after training (3744 vs. 2534: 1210 s)
    - 45 : 5 = ?
      - Faster (3721 vs. 2623: 1100 ms) but more errors (4 vs. 13) specially for “untrained items” (1 vs. 7 errors)
  - Production under temporal constraint
    - 5 x 9 = ? (max 2000 ms),
      - No change for the untrained items (11 vs. 12/25 cr) but gets worse for trained items ! (23 vs. 18/25 cr)
  - Number matching task
    - 5 9 45 ?
      - No interesting effets
- *Global increase of speed, more errors on trained multiplication under temporal constraints*

Simple arithmetic: multiplic. strategies

- Aurélie: 10 y.o., 4th grade, normal score but do not understand multiplication
  - Production task:
    - 4 x 5 = ?
      - Faster after training (2603 ms vs. 2220 ms: 383 ms)
    - 45 : 5 = ?
      - Faster for “trained” items (4282 vs. 3772: 510 ms) but no ≠ for “untrained” items (4079 vs. 4195 ms: + 116 ms)
  - Production under temporal constraint
    - 4 + 5 = ? (max 2000 ms),
      - No effect
  - Number matching task
    - 4 5 9 ?
      - Globally faster for trained items after training (886 ms vs. 635 ms) but not for untrained items
- *Global increase in speed, more pronounced for the trained items in division and number matching task*

Simple arithmetic: conclusion

- *Addition drill*
  - *Specific effect on the trained items, tendency to show fast and automatic activation of these sums*
- *Addition strategy*
  - *Global effect only in speed for solving additions*
- *Multiplication drill*
  - *Global increase of speed, more errors on trained multiplication under temporal constraints*
- *Multiplication strategy*
  - *Global increase in speed, more pronounced for the trained items in division and number matching task (whatever the type of trials)*

Number transcoding

CM: reeducation of transocding

(Sullivan, Maracuso & Sokol, 1996)

- CM: 13 y.o boy
- VIQ = 102, PIQ = 88
- Difficulties in reading
- Difficulties in number processing but arithmetic is OK (except division)

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- Transcoding (% cr)
  - NA => NVO : 79%
  - NA => NVE : 68%
  - NVE => NVO : 89%
  - **NVE => NA: 45%**
  - **NVO => NA: 54%**
  - NVO => NVE: 75%
- Exemples of errors

Three thousand five hundred two => 3.0520 (3,502)
Nine hundred two thousand seventy => 92,70 (902,070)
/Sixty-six thousand one hundred and five/ => 66.15 (66,105)
/Five hundred six thousand one/ => 5.061 (506,001)

=> Syntactical errors

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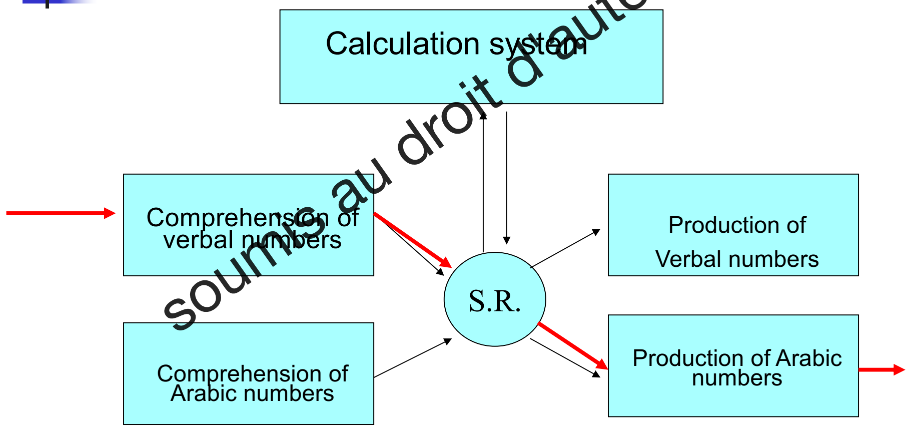
McCloskey' model



- Magnitude comparaison: written VN: 20/21; spoken VN: 18/20

=> Problem in the production of Arabic numbers

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Program

- Working on the transcoding from WVN => AN
  - items from 1-6 digits,
  - not with the X0,000 structure.
- effect on untrained items ?
- Effect on the untrained structure (X0,000) ?
- Effect on the untrained SVN => A
- Specific effect ? If yes, not on
  - AN => SpokenVN or
  - AN => WrittenVN

Goal: built a correct syntactic frame for producing Arabic numbers

- Working with 1- to 3-digit numbers (30 items)
  - Fifty-three => - 5 3
  - One hundred and nine => 1 - 9

H	D	U

- working with 3- to 6-digit numbers (15 items)
- working with 1- to 6-digit numbers(75 items)

HT	DT	T	H	D	U

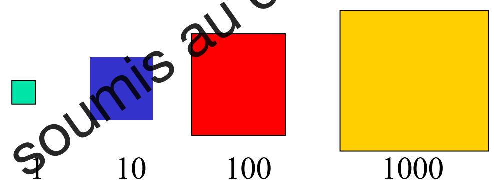
- Direct correction of the errors & explanation

Effects of the reeducation

- WrittenVN => AN: 44 -> 75% re
  - Therapy was efficient
- items X0.000: 13% => 52%
  - Effects generalize to untrained structures
- SpokenVN => AN: 55% => 79%
  - Effect to other tasks using the defective & trained component (Arabic number production system)
- AN => WrittenVN; AN => SpokenVN: ns
  - Effect is specific

transcoding

- For Spoken VN to AN
  - Working SpokenVN to tokens
  - Working tokens to Arabic numbers



- => powerful effect on spokenVN to Arabic

Base 10 representation

Base 10

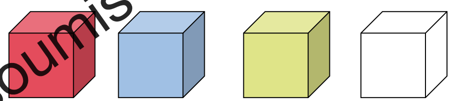
- Working the notion of equivalence
  - Two shoes = a pair of shoes
  - One week = 7 days
  - One hand = 5 fingers
- Base-10 game « monopoly »
  - If you have 10 rooms, you can buy an apartment
  - If you have 10 apratments, you can buy a building
  - If you have 10 buildings, you can buy a district

Emmanuelle Palmers

soumis au droit d'auteur

Base 10

- Base-10 relative to the position in space
  - 10 white tokens in the box 1 is 1 yellow tokens in box 2
  - 10 yellow tokens in box 2 = 1 blue tokens in box 3
  - 10 blue tokens in box 4 is 1 red tokens in box 4



Box4 box3 box2 box1

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Compréhension de l’opération

- Compréhension de l’opération
  - 7 - 3 avec des jetons ?
    - L’enfant prend 7 jetons, puis 3 et dit “j’enlève 3” => il reste 7
  - 4 : 2
    - j’ai deux personnes à qui je donne 4
- Difficultés au niveau du formalisme
  - Travailler sur le vocabulaire: plus, moins, avant, après
  - Travailler des calculs sans nombres

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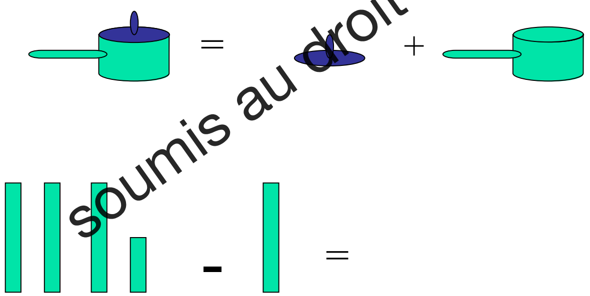
- Calculus sans nombres



transcoding

- Certains enfants ont des difficultés avec le “mille”
  - Sept mille six cents => 7 1600
  - Pour exprimer, par écrit, le correspondant du “mille”, on leur propose d’écrire “m” et puis “.”
    - 7m600
    - 7.600