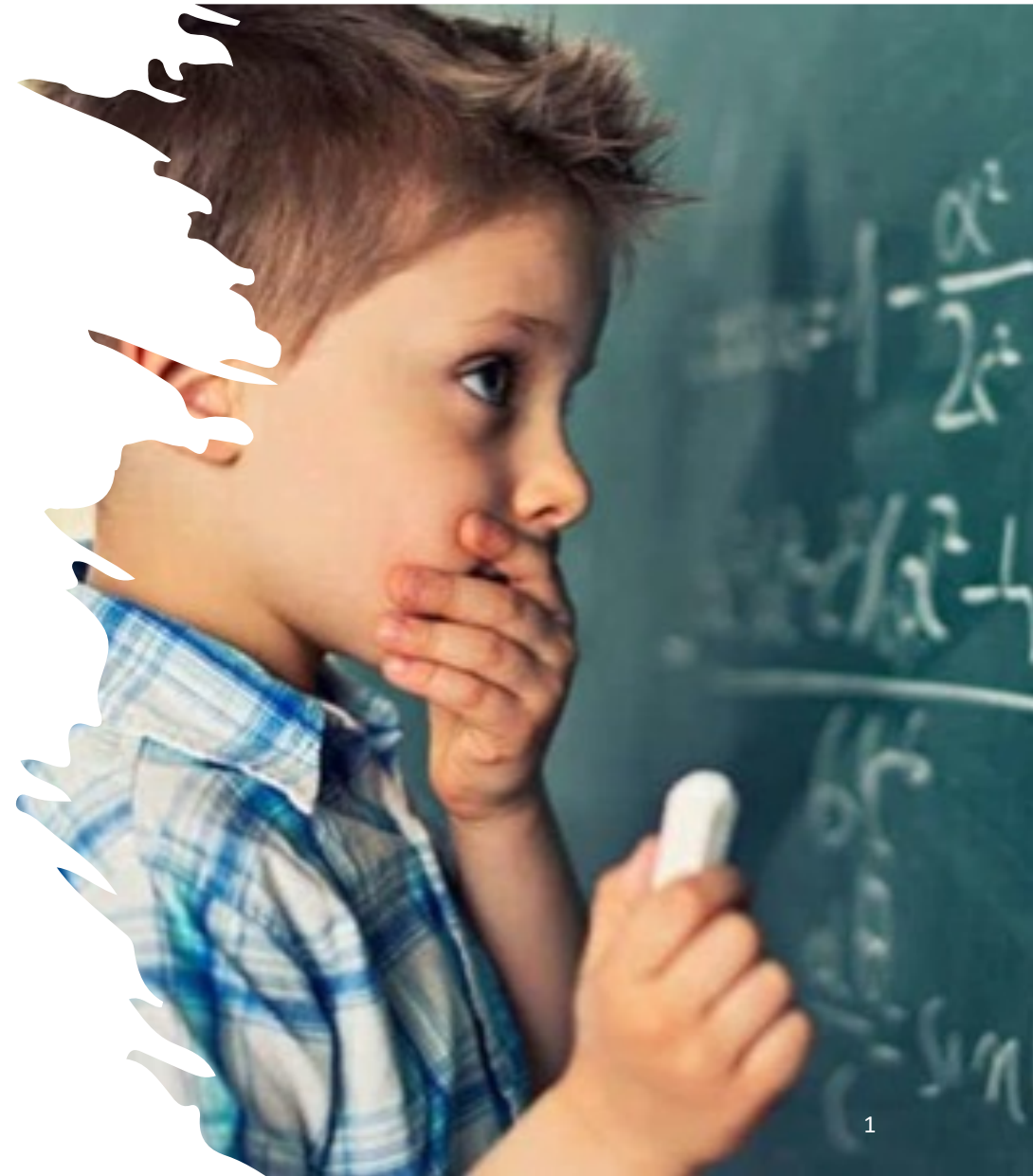


Math anxiety and working memory

Jean-Philippe van Dijck



Who is on your PC screen?

Jean-Philippe van Dijck

- Professional bachelor in (applied) psychology
- Master in experimental psychology
- PhD in psychology

- Lecturer and researcher
 - Department of applied psychology @Thomas More
- (Visiting) research professor
 - Department of experimental psychology @ Ghent University



Numbers and math are everywhere

Clock reading
(in theme park)

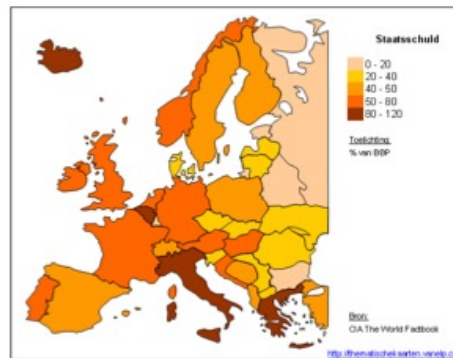
Charlie is visiting the fun fair.



This is when he arrives at the fair. 5 minutes later he is on the roller coaster, what time is it?



Gouvernemental depth



Speed limits

Maths really count

low numerical abilities



low income



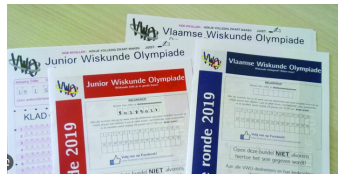
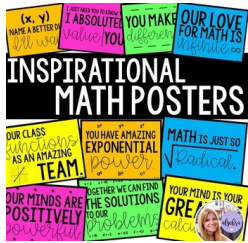
unemployment



physical illness

Math in the focus of attention

How to increase interest and motivation?



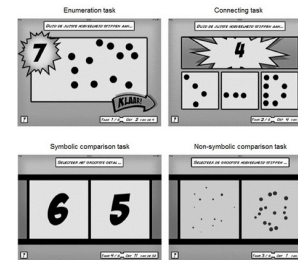
How to improve our cognitive abilities?



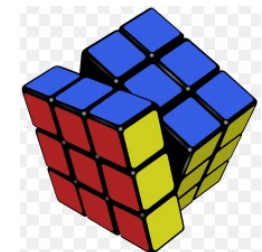
Working memory



Metacognition



Number skills



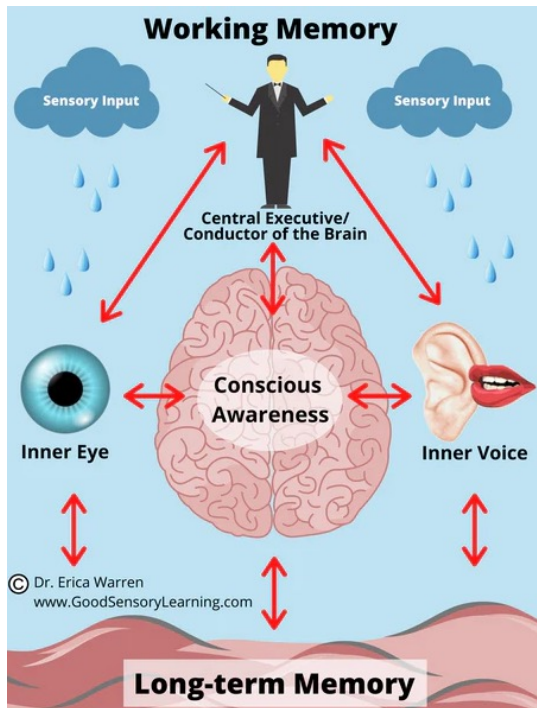
Spatial abilities

Working memory and mathematics

Working memory models

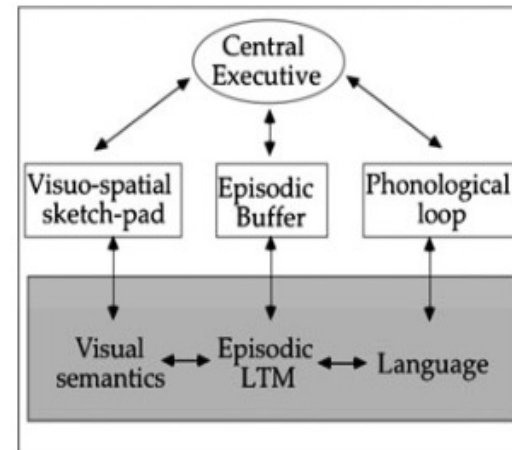
Standard Memory Model

(Atkinson & Shiffrin, 1968)



3 partite WM model

(Baddeley & Hitch, 1976;
Baddeley, 2000)



Central executive

- Distribution & gate keeping

Visuo-spatial Sketch pad

- Visual images, cognitive maps & spatial locations

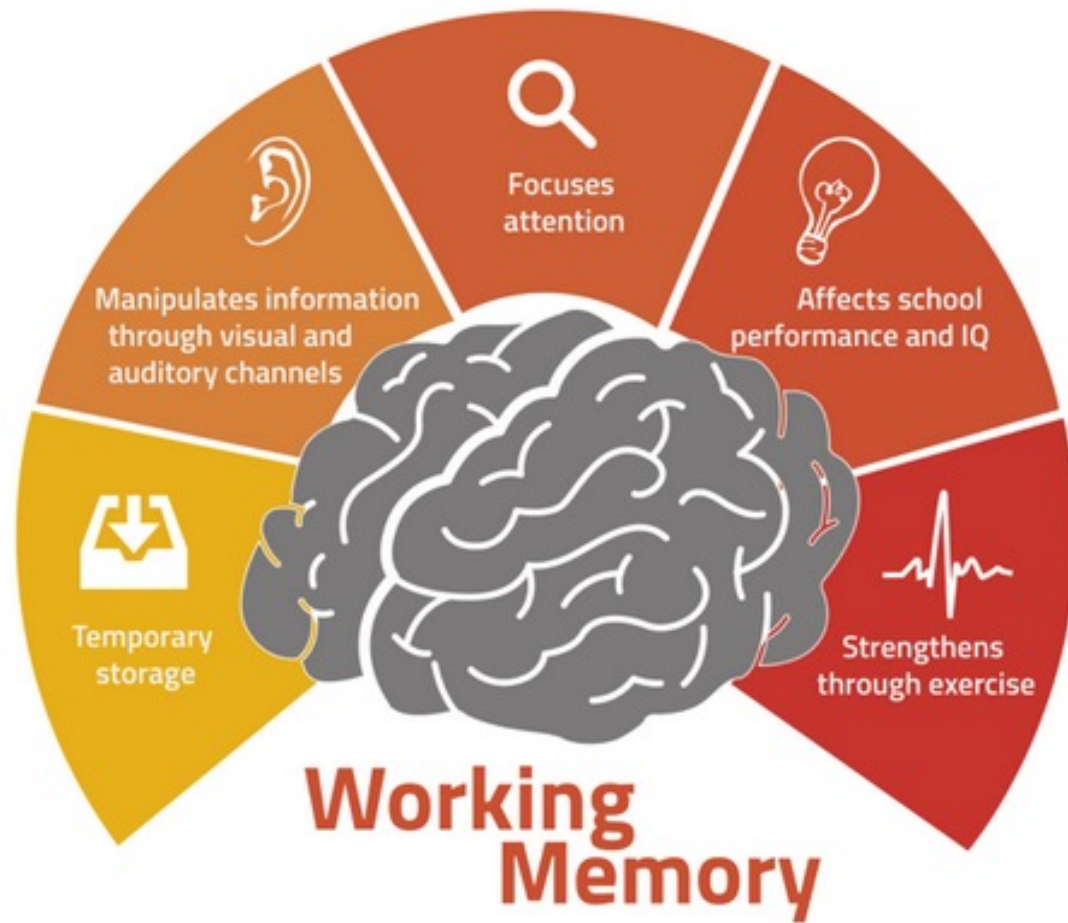
Phonological loop

- Verbal patterns in acoustic form

Episodic buffer

- Connecting visuo-spatial & phonological info to a coherent episode

Limited capacity and duration



From: <https://brainfit.com.sg/types-of-memory/>

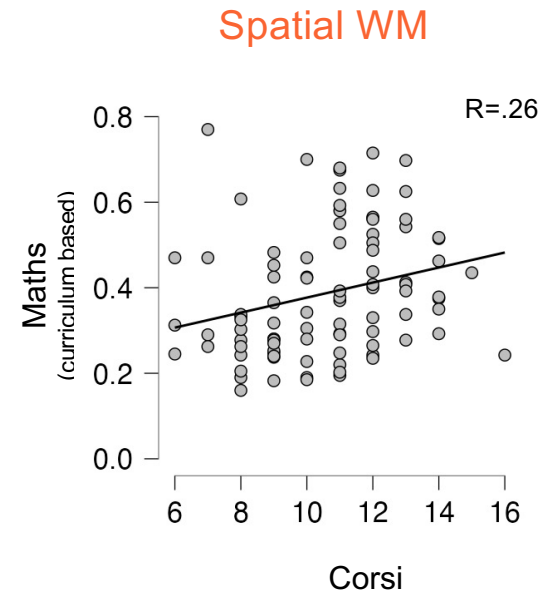
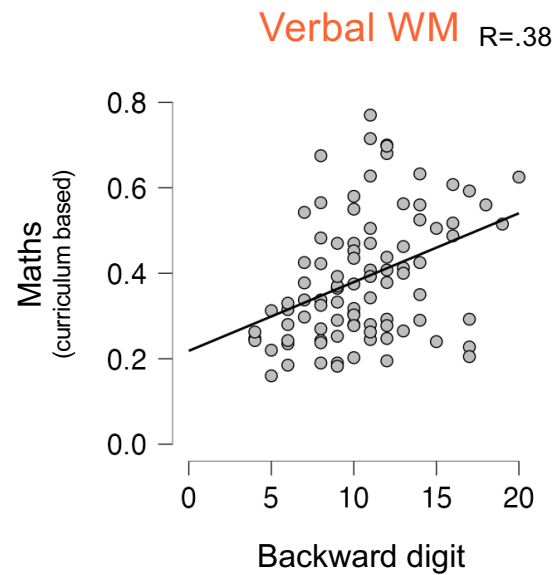
WM capacity is related to math performance

Several meta-analyses/ reviews exist showing a significant (causal) link between mathematical abilities WM capacity and WM functioning

- Raghobar et al., Learning & individual differences, 2010
- Friso-van den Bos et al., Educational Research Review, 2013

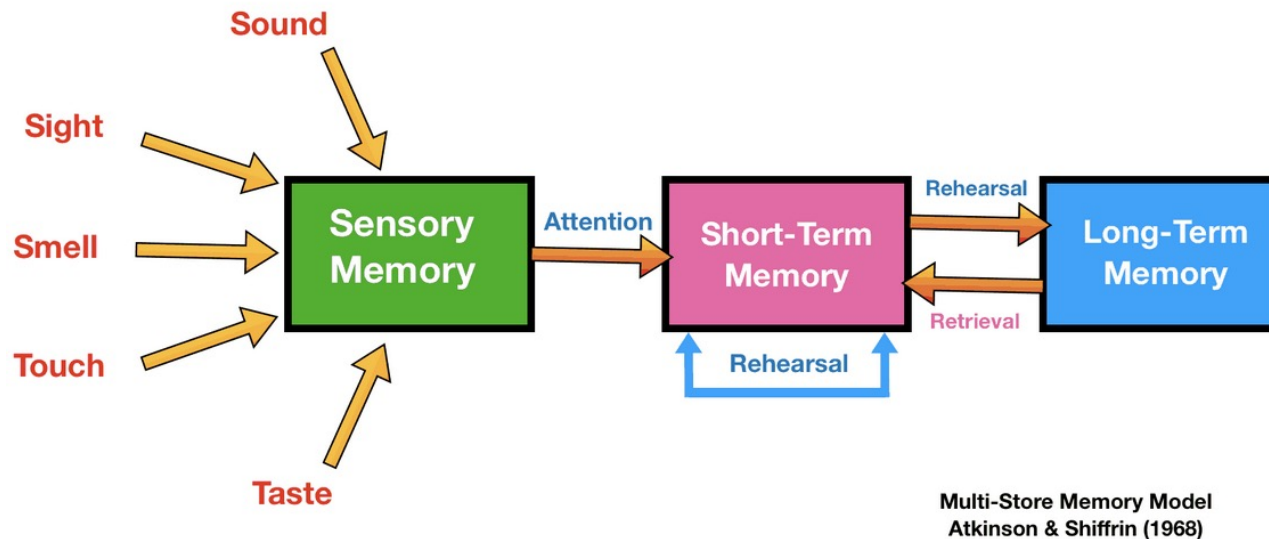
WM capacity is related to math performance

N=93 applied psychology students



→ Higher verbal and spatial WM capacity = better math performance

Sequences of ordered events

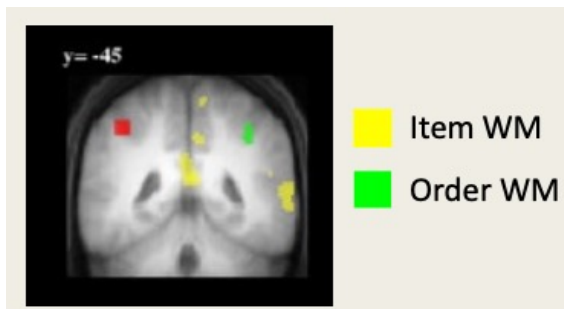


Memorizing the temporal structure of events is necessary for adaptive behaviour:

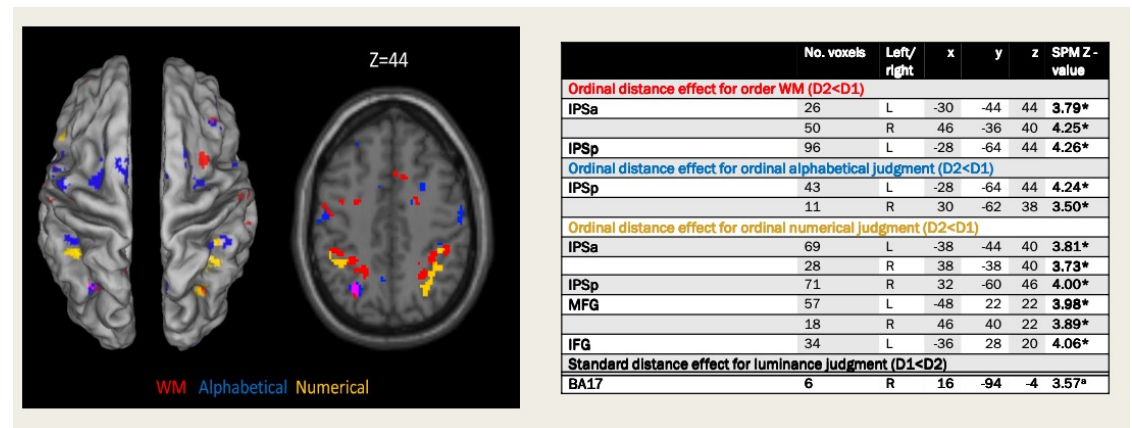
- to understand the world
- to structure our actions and thoughts
- to predict the world
- to plan the future

Serial order processing in memory

Dedicated neural substrates, shared between different ordinal representations



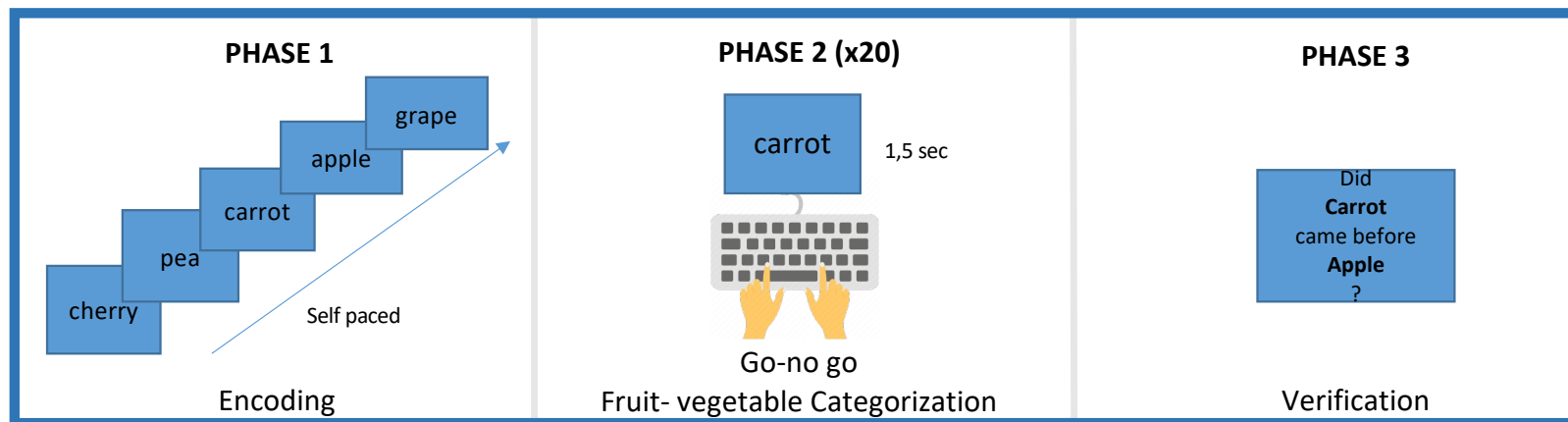
Majerus, 2006



Attout, 2021

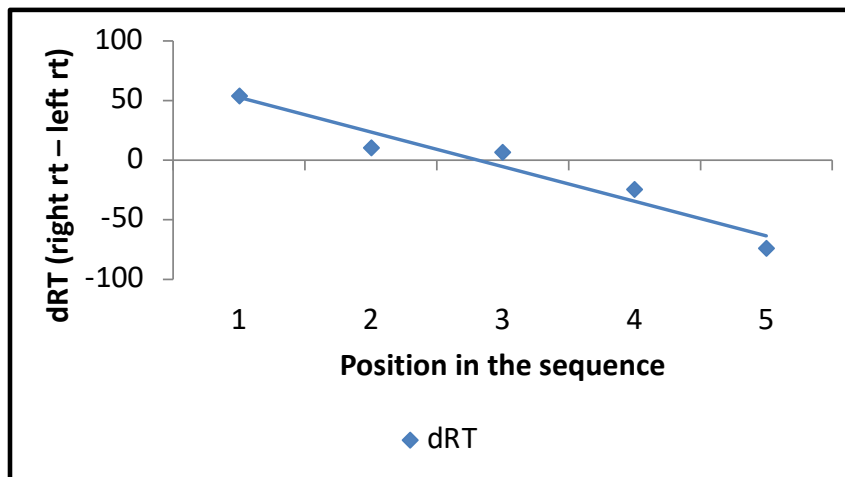
➔ Serial order is a specific component, independent from the memory of item info

Maintanance of serial order



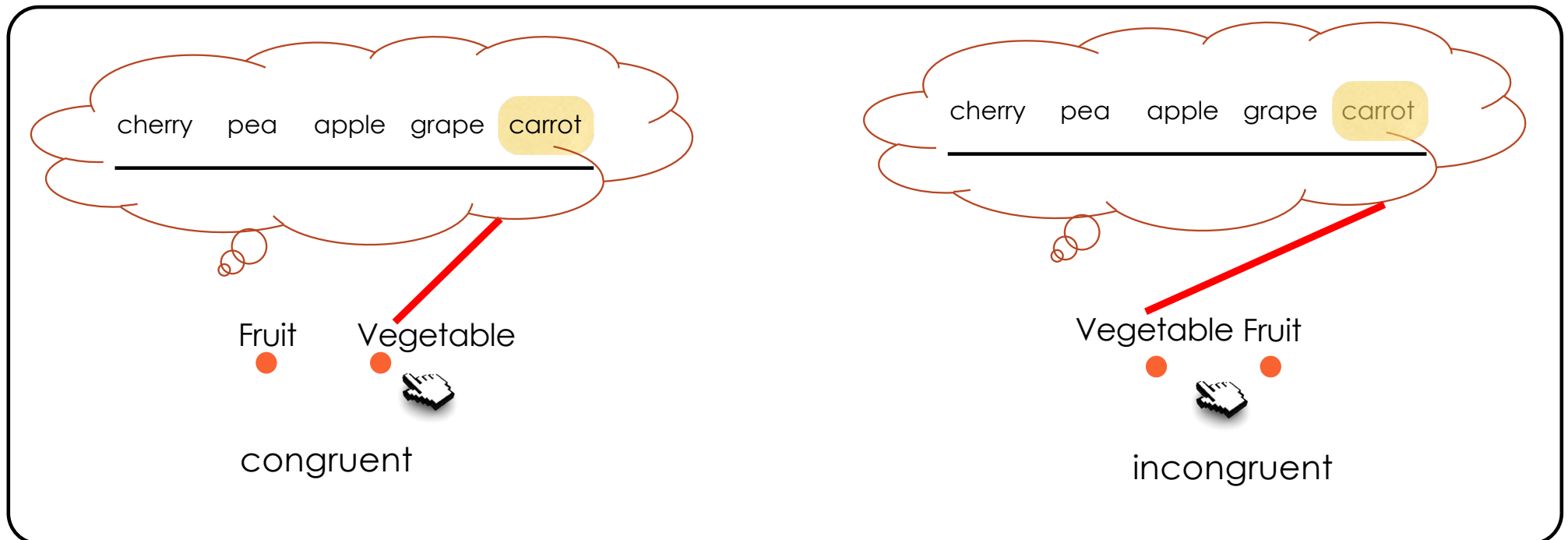
→ Serial order is mapped on a horizontal mental memory line

The Working Memory Line



→ Left-to-right spatial coding
Expressed in a negative slope

The Working Memory Line

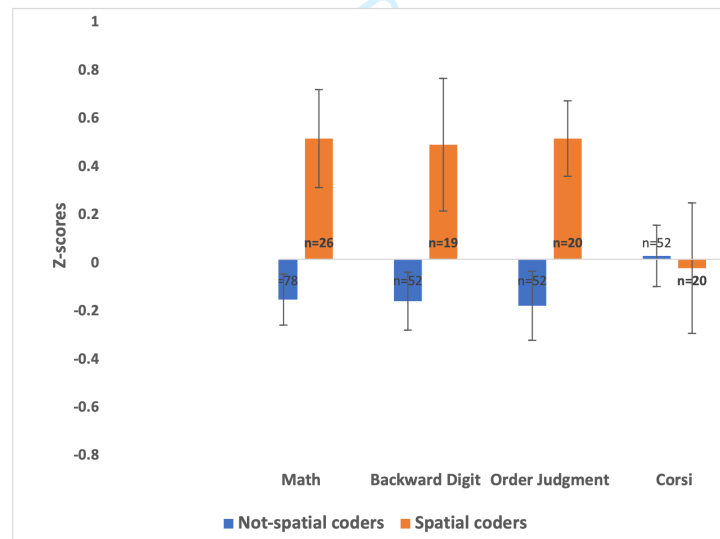


The Working Memory Line of an individual



Functional role of the WML

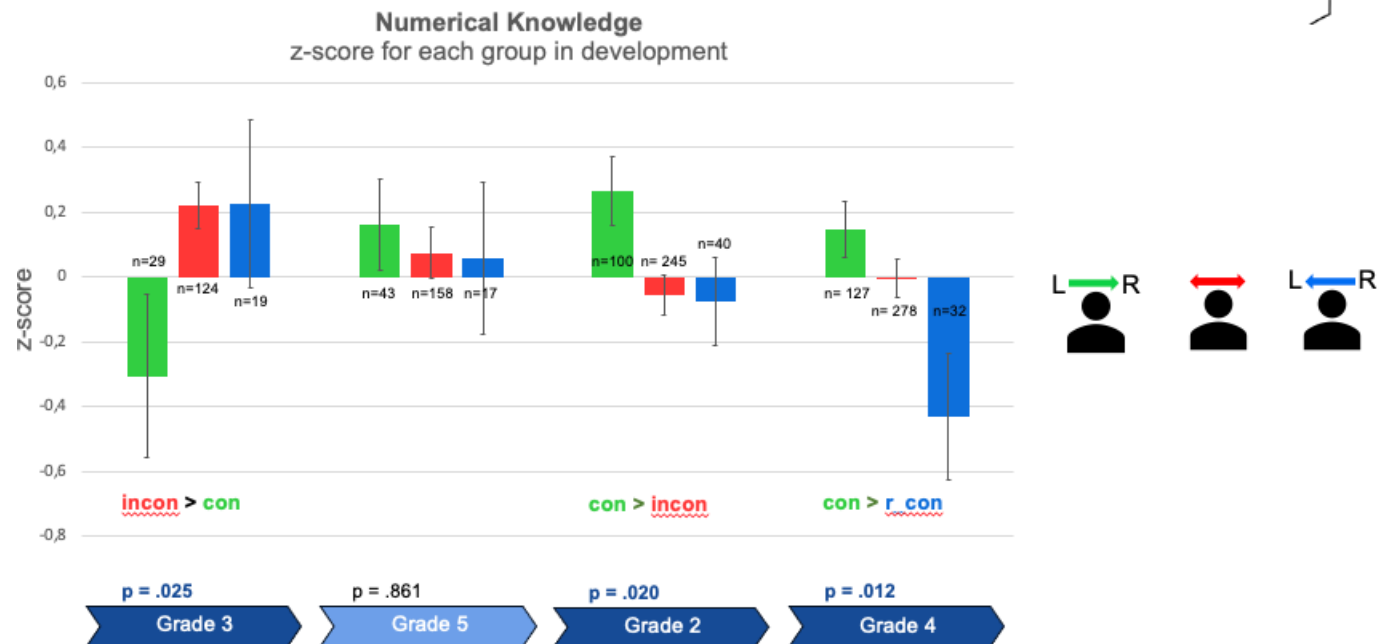
Hypothesis: spatially organizing your “mental workspace” is beneficial for WM functioning and tasks depending on it.



→ Organizing WM on a line is associated with better WM functioning

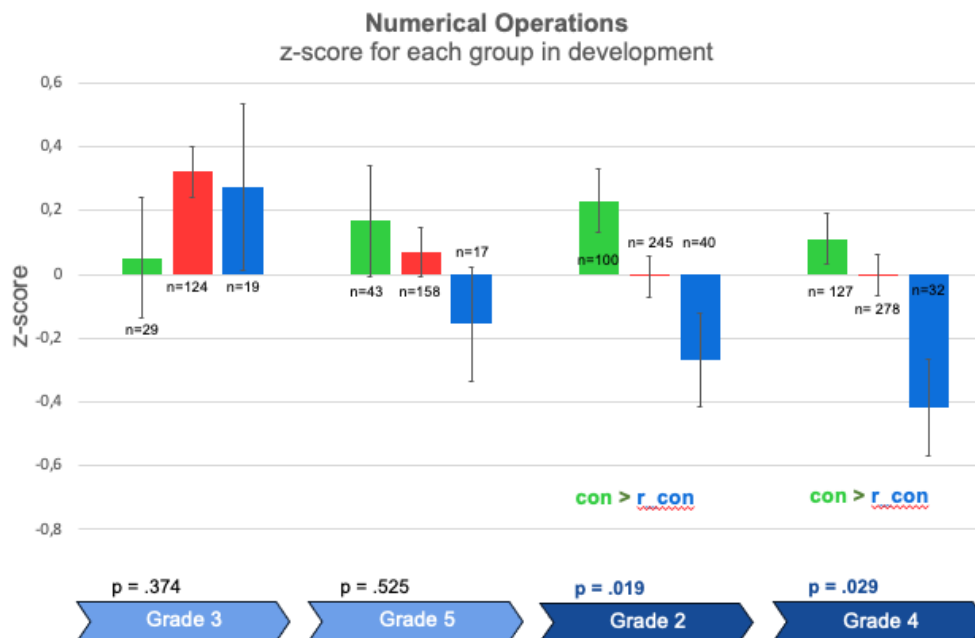
Functional role of the WML

WML: NUMERICAL KNOWLEDGE



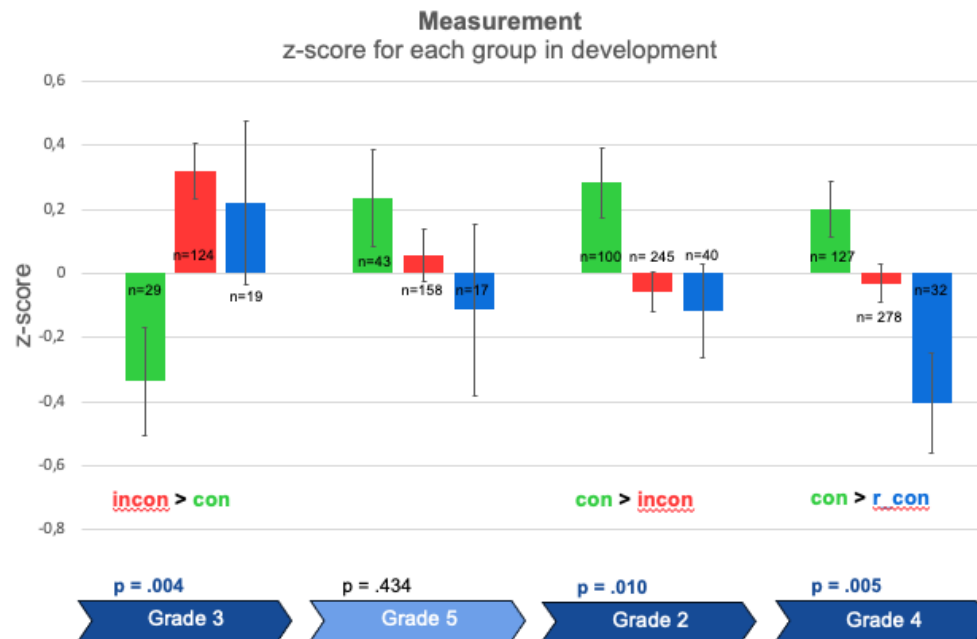
Functional role of the WML

WML: NUMERICAL OPERATIONS



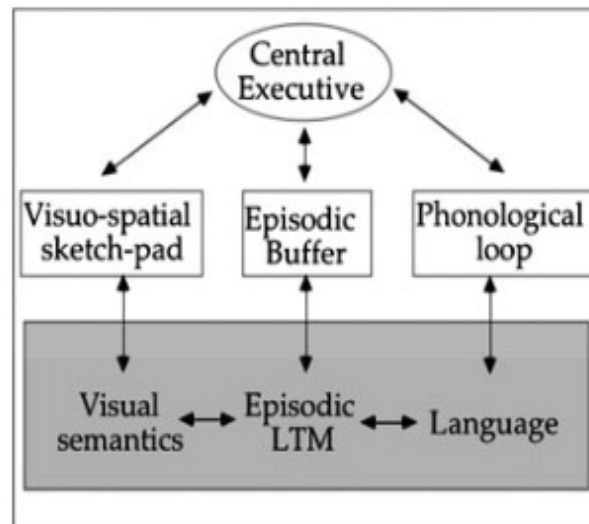
Functional role of the WML

WML: MEASUREMENT



→ Organizing the WML according to our reading habits → better mathematics

WM and mathematics



→ All aspects of WM functioning are related to mathematics

Working memory and mathematics anxiety

$$f(x) = x^2 + 2x - 3$$
$$\Delta = b^2 - 4ac$$
$$\Delta = 4 + 12 = 16$$
$$x_{1,2} = \frac{-b \pm \sqrt{\Delta}}{2a}$$
$$x_{1,2} = \frac{-2 \pm \sqrt{16}}{2} = \frac{-2 \pm 4}{2}$$
$$x_1 = \frac{-6}{2} = -3 \quad x_2 = \frac{2}{2} = 1$$



Do YOU suffer from math anxiety?

Your not alone!

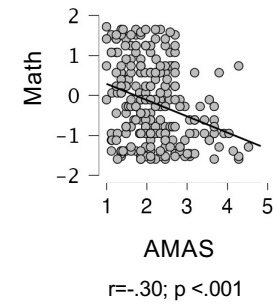
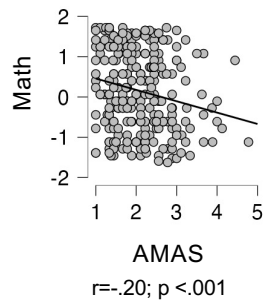
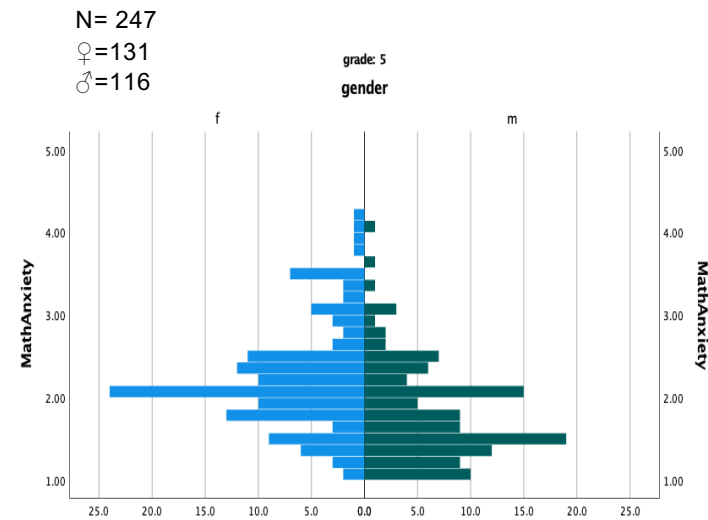
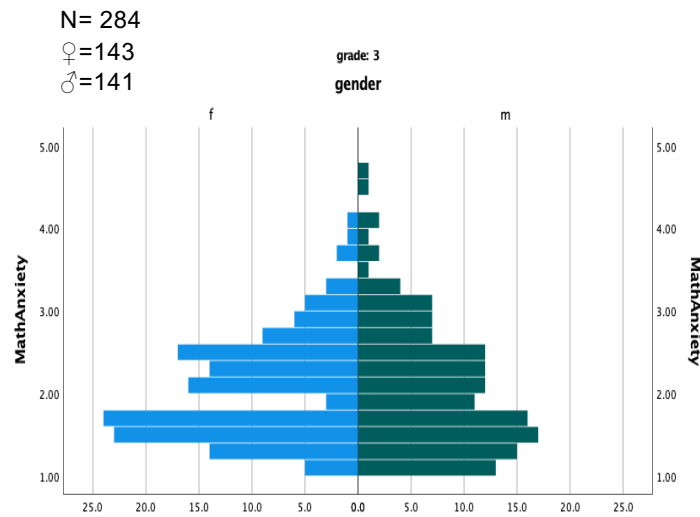
Math Anxiety

- Around 20% of the population (sometimes) experience feelings of apprehension, dislike, tension, worry, frustration, and fear when performing mathematical tasks
 - Learning anxiety, test anxiety and anxiety for the teacher
- For some this has a positive effect on math performance, for the majority not

Your not alone!

Primary school

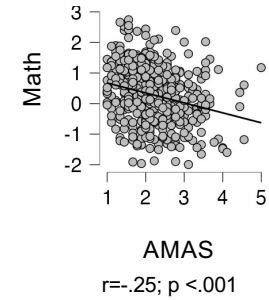
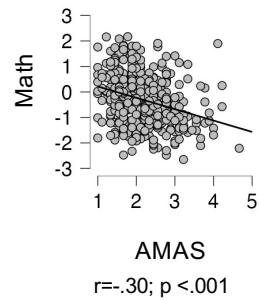
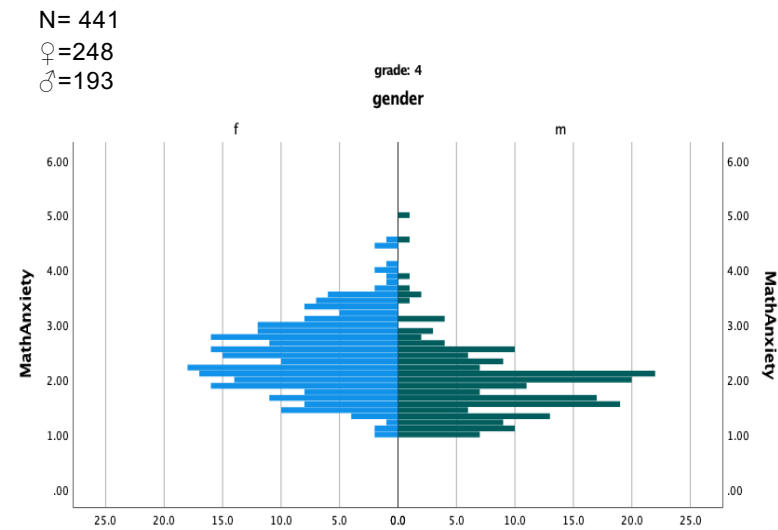
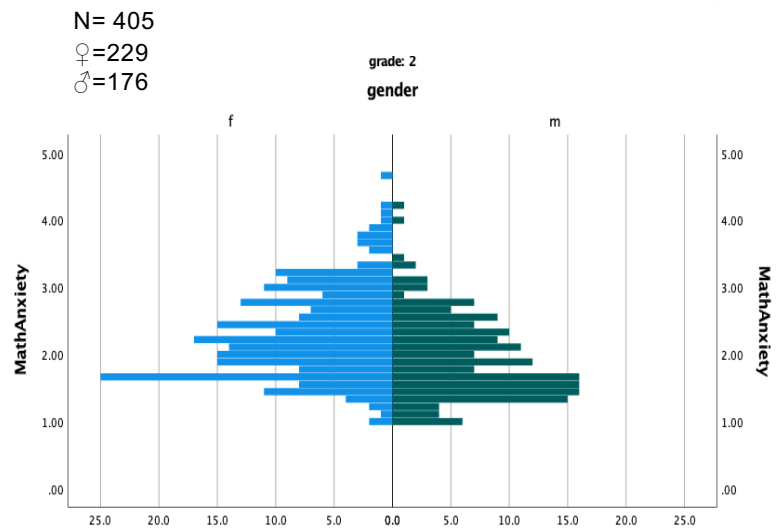
(8 and 11 year old's)



Your not alone!

Secondary school

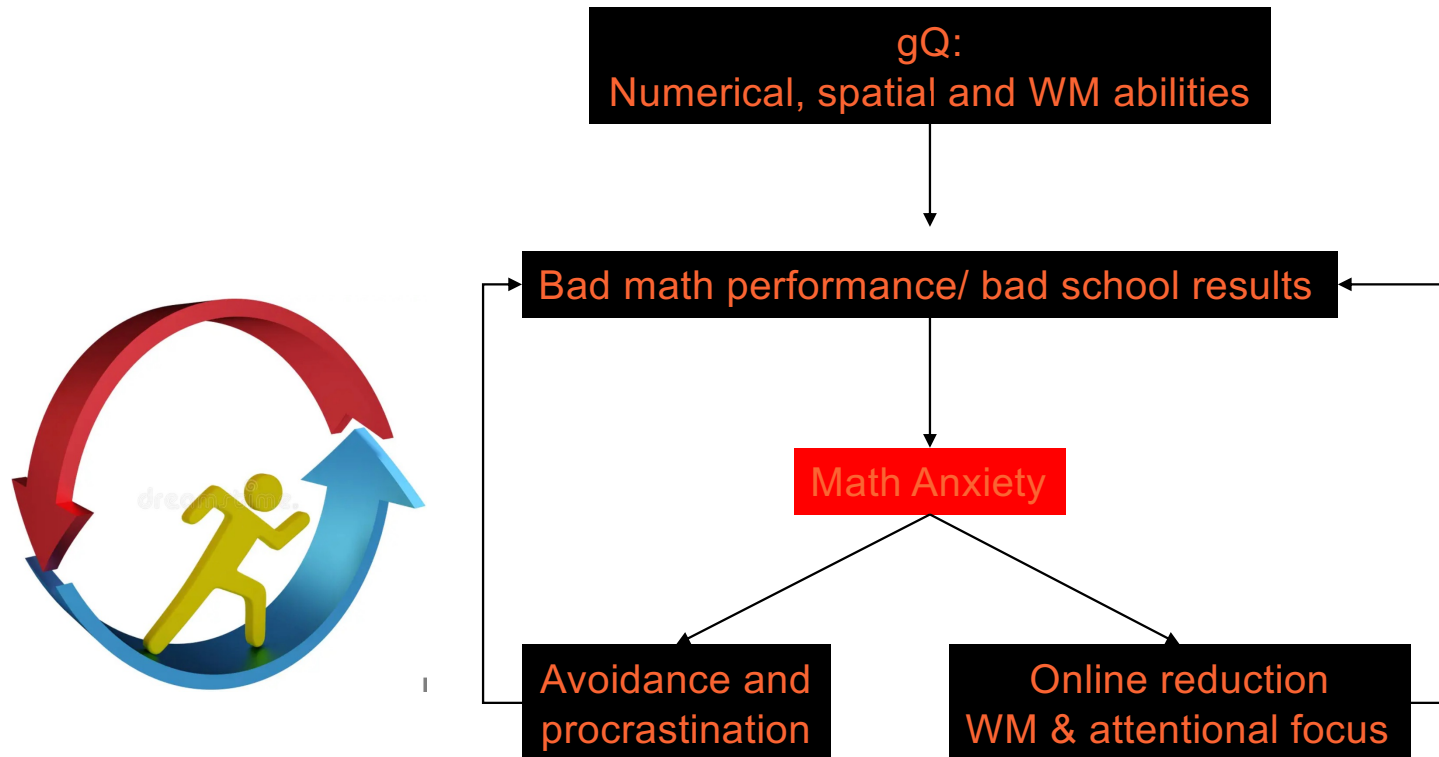
(13 and 15 year old's)



Math anxiety is a genuine psychological construct

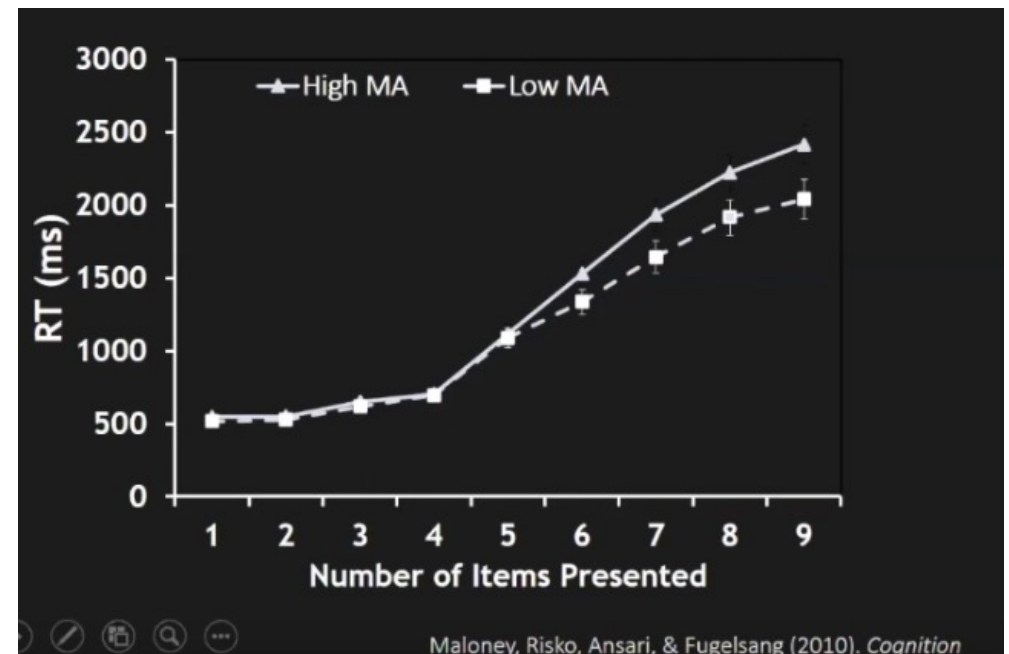
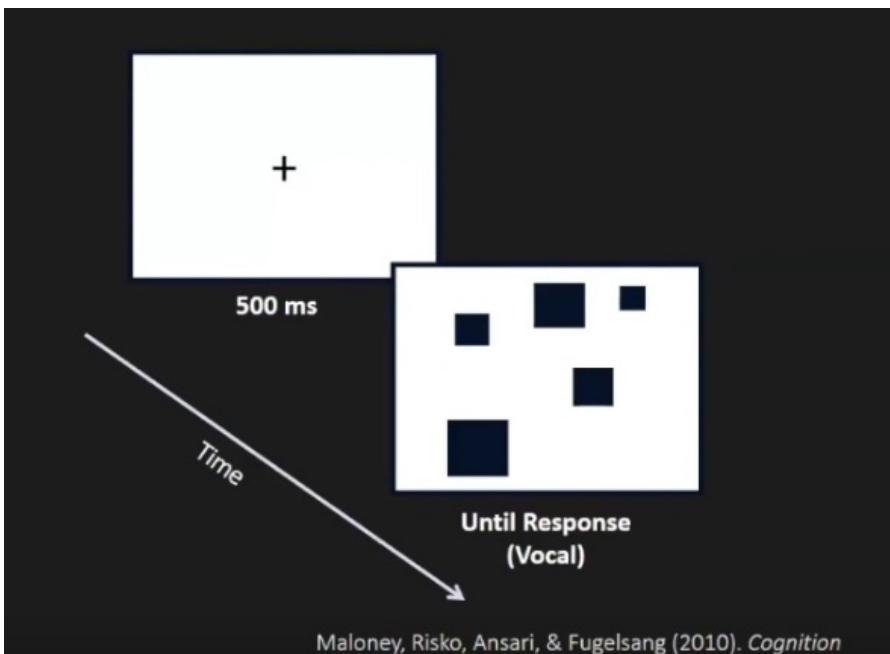
- Independent of general anxiety
 - Limited correlation with IQ
 - Starts around 6 years of age, peaks around 13 and stays (when not treated) constant until adulthood
 - Activates the “threat detection brain network” of perception and physical pain
-
- Has an impact on math performance
 - Procrastination, avoidance
 - Depletion of cognitive resources
 - Extra motivation

Development of math anxiety



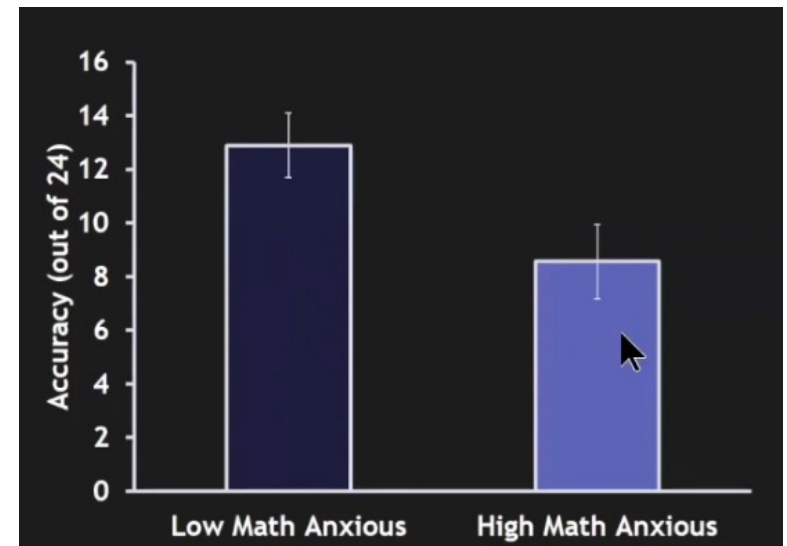
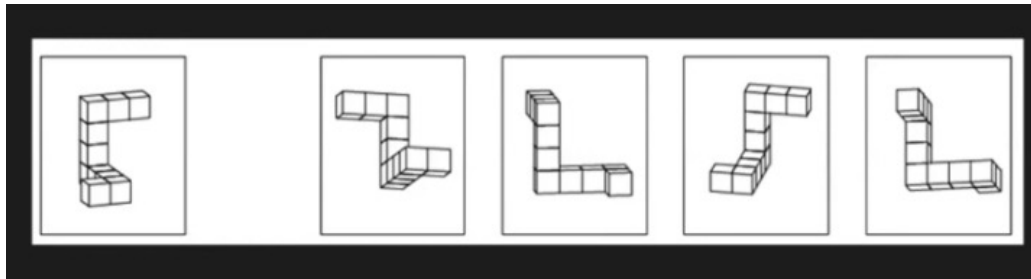
Adapted from Maloney et al (2015) Handbook of motivation at school. 2e ed.

Math anxiety and basic number skills



➔ High MA individuals show lower performance above subitizing range

Math anxiety and basic spatial skills

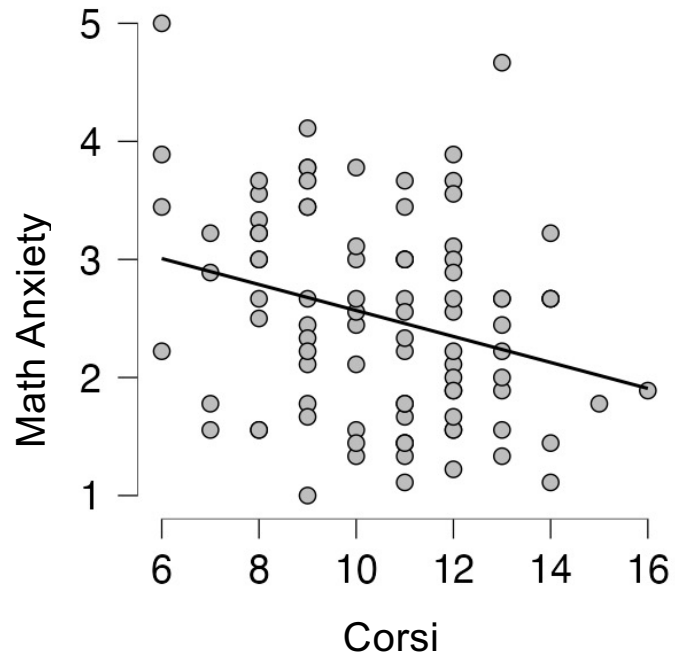


→ High MA individuals perform lower on mental rotation

Math anxiety and WM

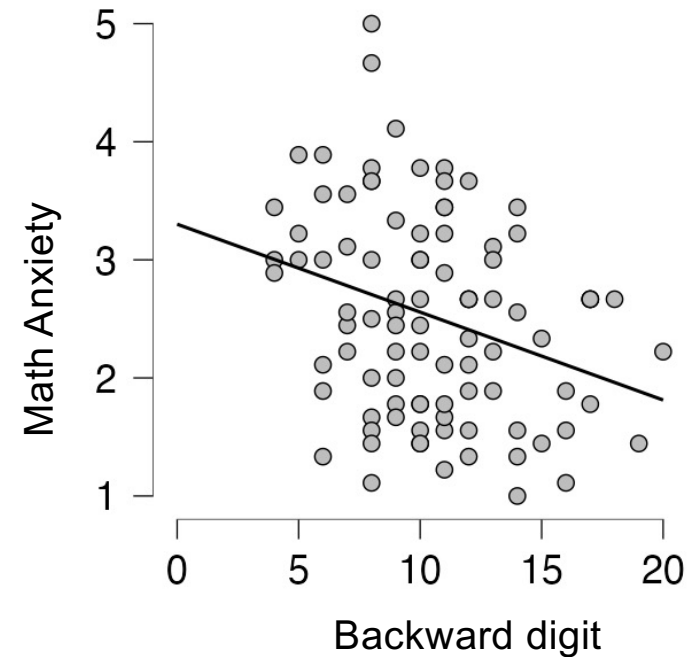
Spatial WM

$r = -.28, p < .01$



Verbal WM

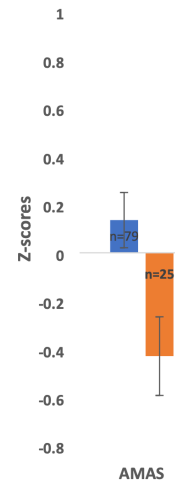
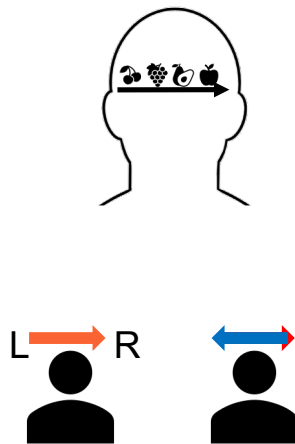
$r = -.30, p < .01$



➔ High WM capacity is associated with lower levels in MA

Math anxiety and WM

Working memory line and MA

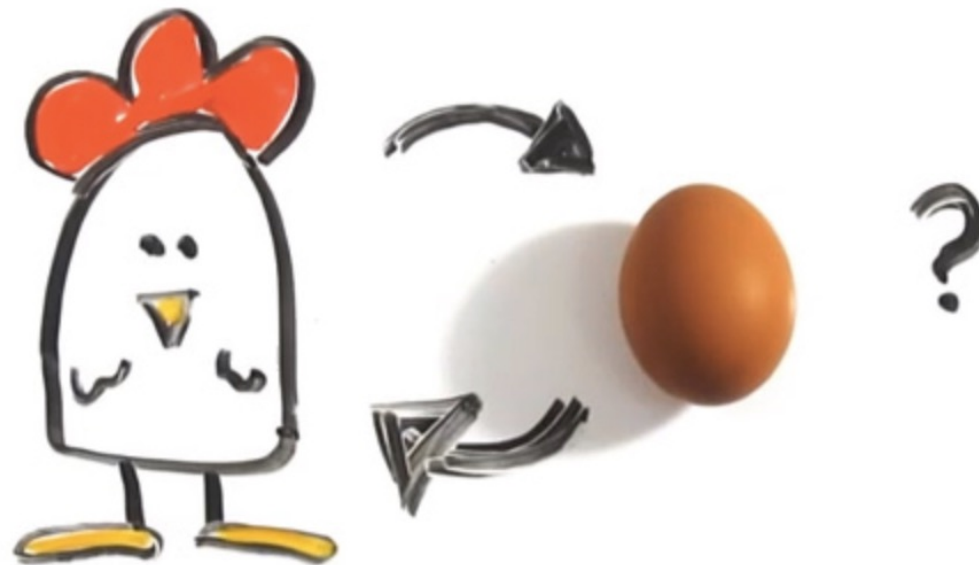


■ Not-spatial coders ■ Spatial coders

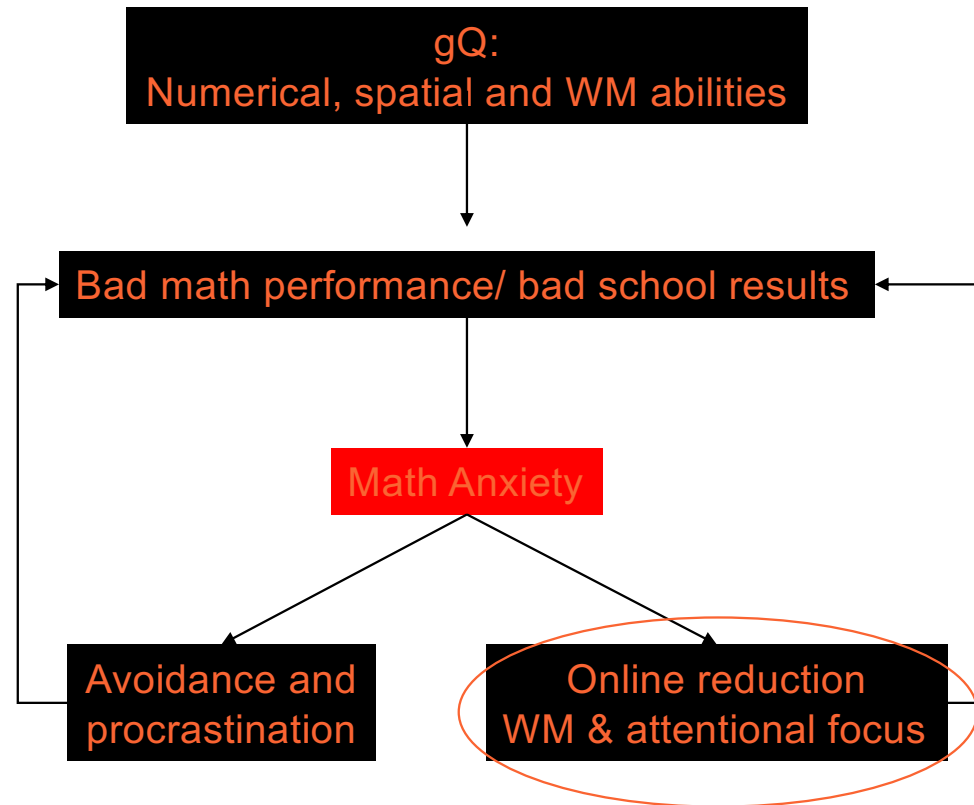
➔ Organizing WM on a line is associated with less MA

Important limitation

- Longitudinal or training studies needed to demonstrate causal relationships



Development of math anxiety



Adapted from Maloney et al (2015) Handbook of motivation at school. 2e ed.

Online reduction attention and WM resources

Cognitive theories in MA attribute the MA – performance link to various cognitive factors, such as **attentional control** and **working memory**

Attentional Control Theory (ACT):

- MA increases the allocation of attentional resources to worry, this reduces the attentional focus on the current task (Eysenck et al., 2007)



Online reduction attention and WM resources

Supervisory attentional system (Shallice)
Two cognitive modes

~~Controlled~~

~~Purposeful focusing of attention and directing actions in e.g. new situations, high task difficulty, problem solving, breaking habits~~

Automatic processing

(over) learned automatic processing of stimuli (schemas & procedures)

- More distracted by stimulus driven information
- Less inhibition of irrelevant information etc.

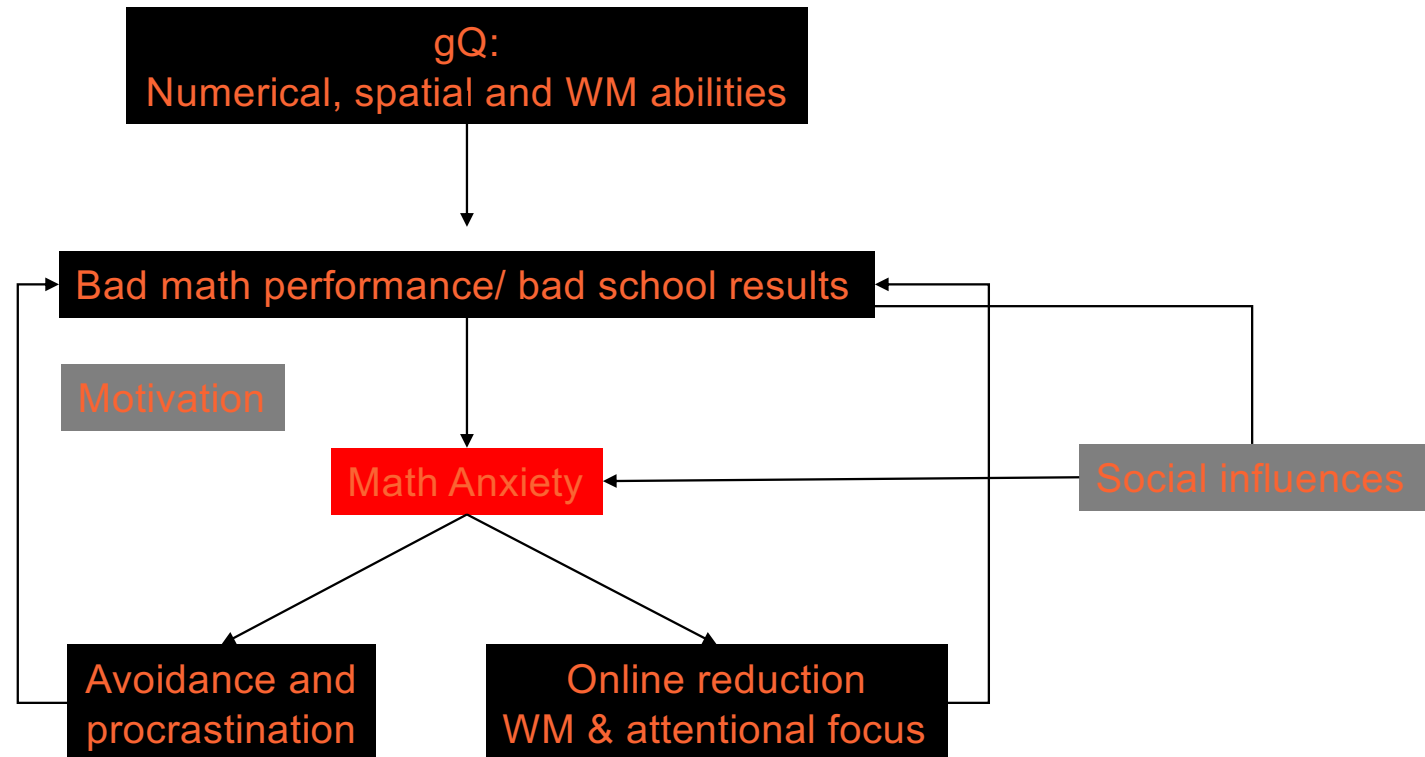
Math anxiety & math performance

Processing Efficiency Theory (Eysenck & Calvo, 1992):

- MA generates intrusive and worrying thoughts
 - These consume the (limited) WM resources
- ➔ less WM resources available for the math tasks at hand
- MA most detrimental for WM intensive tasks
 - People with high WM capacity suffer most from MA because of the use of more WM intensive problem solving strategies



Development of math anxiety



Adapted from Maloney et al (2015) Handbook of motivation at school. 2e ed.

Mediating variables

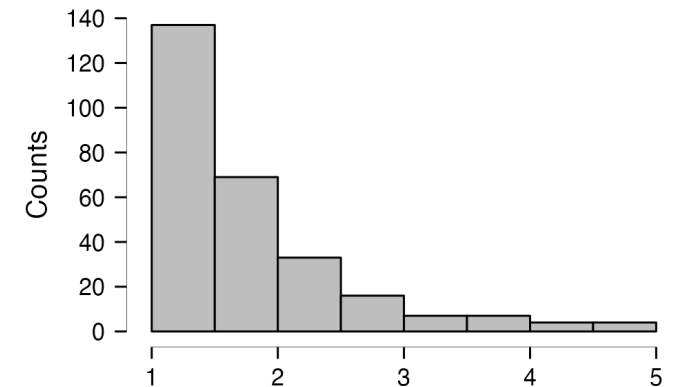
Social variables

- Math attitude parents
- Math attitude teachers
- (Gender) stereotypes

- Proximity teachers (higher education)
- Teachingstyle (cfr. anxiety for math teachers)

Motivation

- Believe in the importance of math and the willing to learn it
- Moderate MA in combination with high motivation can have a positive effect on performance
- To much mathematical knowlegde can have an adversive effect (being aware of incompetence)



9% of primary school teachers in Flanders report moderate anxiety for teaching maths

→ **Complex picture with many mediating variables**

How can MA be “treated”?

Dealing with MA & the negative effects

- Cognitive reappraisal
- Relaxation techniques (breathing, mindfulness)
- Writing therapy

Growth mindset

- Maths/statistics tutoring
- Learning to study -> including to avoid procrastination
- Increasing motivation

Teaching style

- Focus on understanding (instead of mathematical formulas)
- Discourage procrastination
- Possibility to ask (anonymous) questions
- Use of humour
- Use of real-life examples
- Teacher immediacy



Thank you!

Jean-Philippe.vanDijck@thomasmore.be