

Math and Executive Function Skills in Children with Mathematics Difficulties

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DanSMA
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Duluth

Average Hi / Low Temps

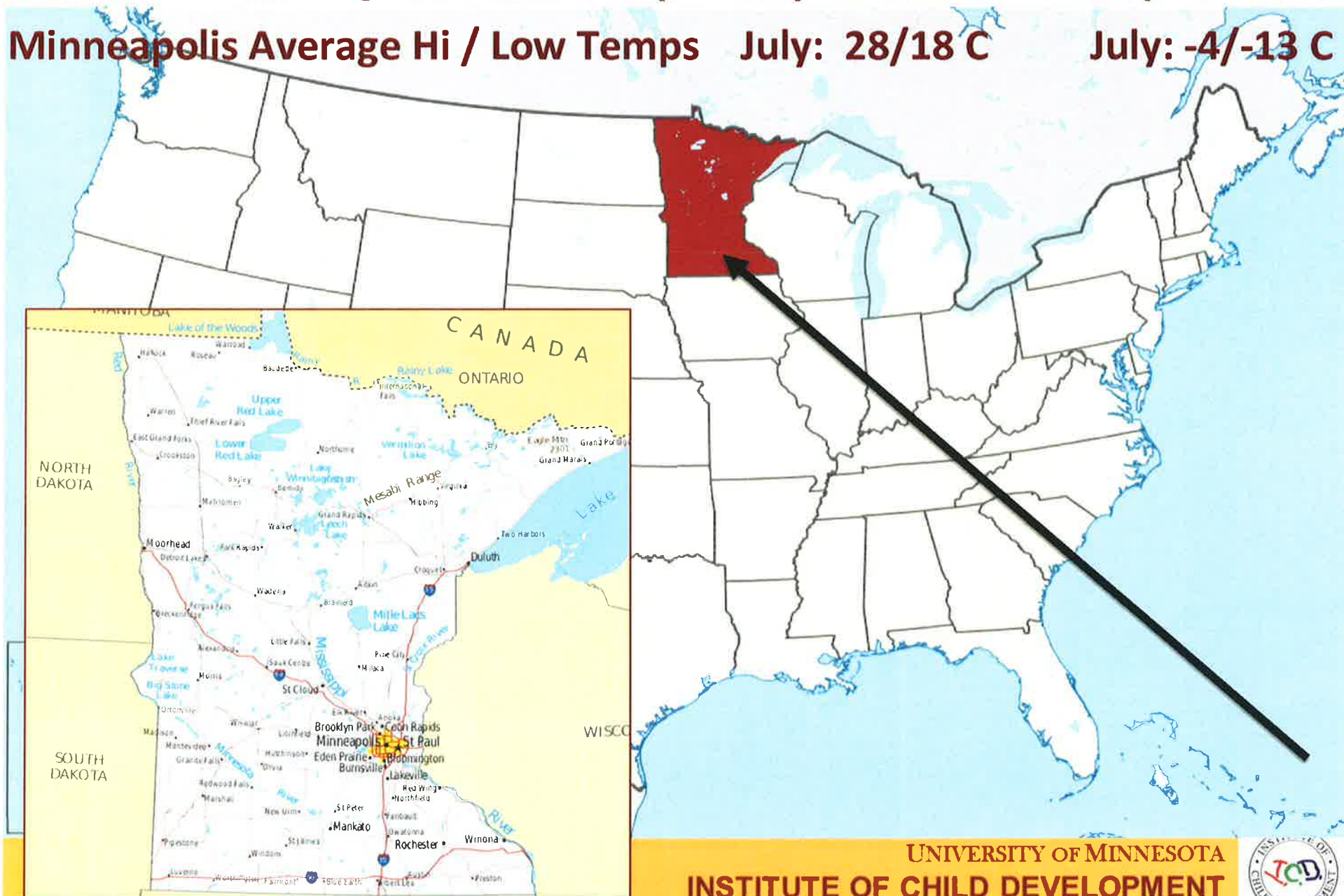
July: 24/13 C

July: -7/-17 C

Minneapolis Average Hi / Low Temps

July: 28/18 C

July: -4/-13 C



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Executive Function - Definition

- A set of skills that allow people to control their own behavior
- Goal-oriented skills that require effort (not automatic)
- “higher level” cognitive processes

Executive Function - Components

Cognitive Flexibility (shifting)

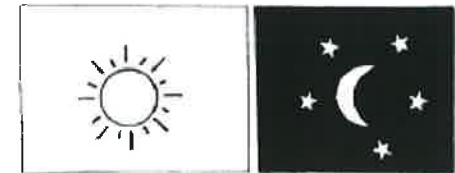
The flexibility to consider multiple perspectives or shift tasks, directions, response sets (“cognitive flexibility”)

Working Memory (updating information, mental work space)

The ability to simultaneously think about and manipulate information in our “mental workspace” (verbal or visual info) **DIGIT SPAN**

Inhibitory Control (response inhibition)

The ability to resist making an automatic or desired



Sustained attention - The ability to maintain attention during a task

Executive Function - Development

- Develops rapidly in preschool years (3 to 5)
- Continues to develop through early adulthood

Whether a problem has EF demands depends on the student's math knowledge and skills

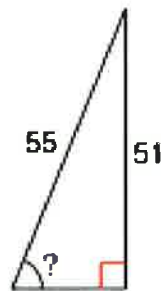
$$7 + 4 + 8 =$$

$$p - 1 = 5p + 3p - 8$$

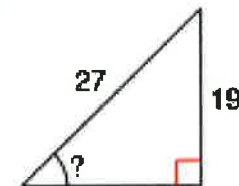
$$(2a - 1)(8a - 5)$$

Find the measure of the indicated angle to the nearest degree.

7)



8)





Whether a problem has EF demands
depends on the student's math knowledge and skills

$$2 + 3 = \underline{\hspace{2cm}}$$

$$1\frac{3}{4} \div \frac{1}{2} = \underline{\hspace{2cm}}$$

Even tasks like counting
or the Numbers Sets
Task (to the right) can
pose EF demands,
depending on the child's
skill level,

Circle all of the groups that add up to 3.
Work as quickly as you can.

3

→

★	★
---	---

●●●●	●●●●
------	------

→

▲▲▲▲	▲▲
------	----

◆	◆
---	---

→

2	1
---	---

4	7
---	---

→

2	8	1
---	---	---

★	★	★
---	---	---

Geary DC, Hoard MK, Nugent L, Bailey DH (2013)

Developmental Changes in Mental Arithmetic

Rivera et al., 2005

Ages 8.5 to 19 year olds
(mean = 13 years)
(typically developing)

Measured activation during
Arithmetic *minus* Control

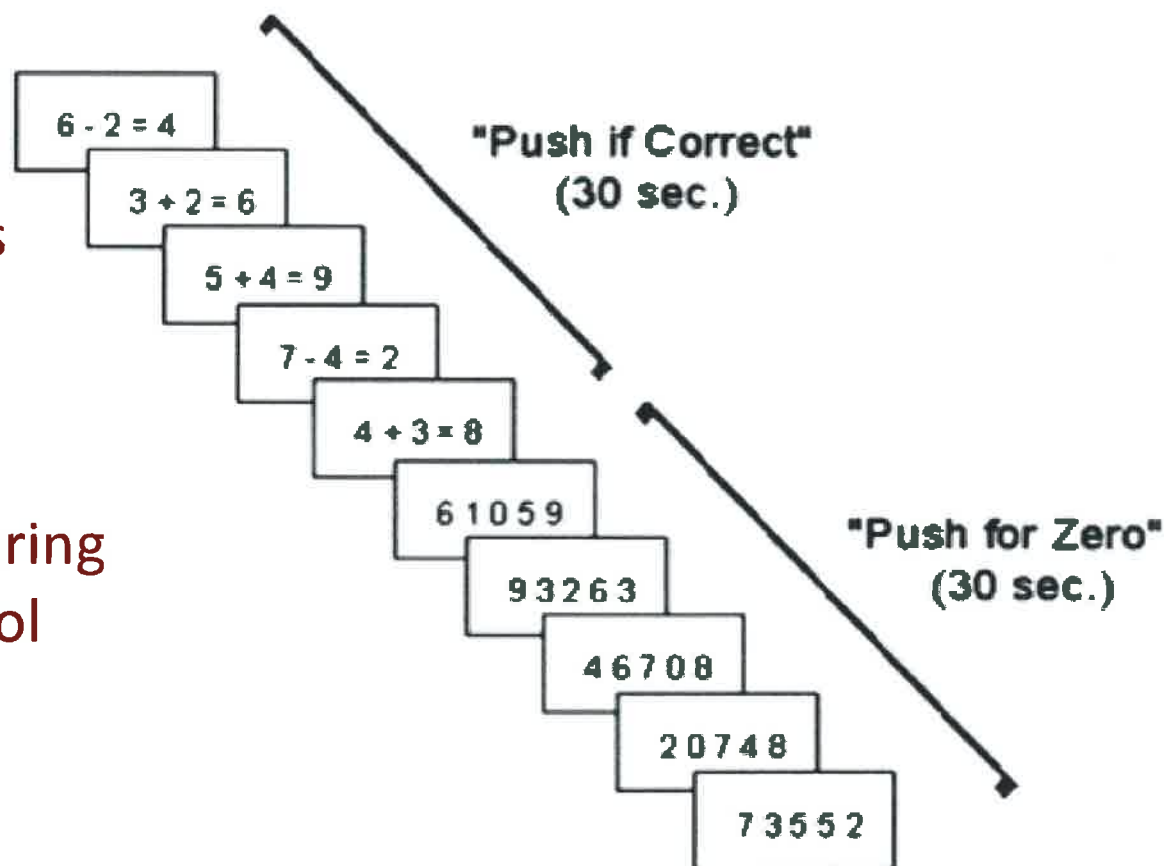
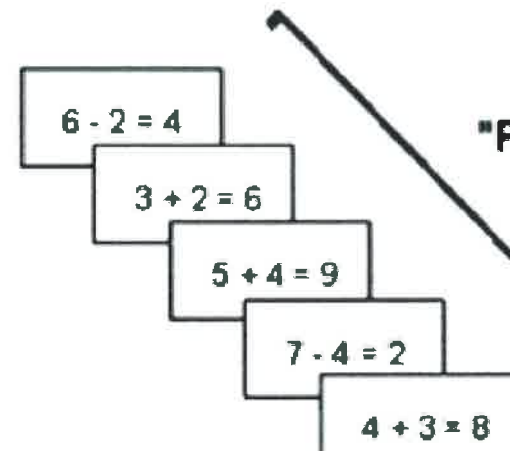


Figure 1. Schematic of task design, showing blocks of experimental and control trials.

Developmental Changes in Mental Arithmetic: Evidence for Increased Functional Specialization in the Left Inferior Parietal Cortex

Rivera et al., 2005



Areas of **increased**
Brain activity with age



Areas of **decreased**
Brain activity with age

Executive function skills :

- promote *doing* math (building proficiency)
- promote *learning* math

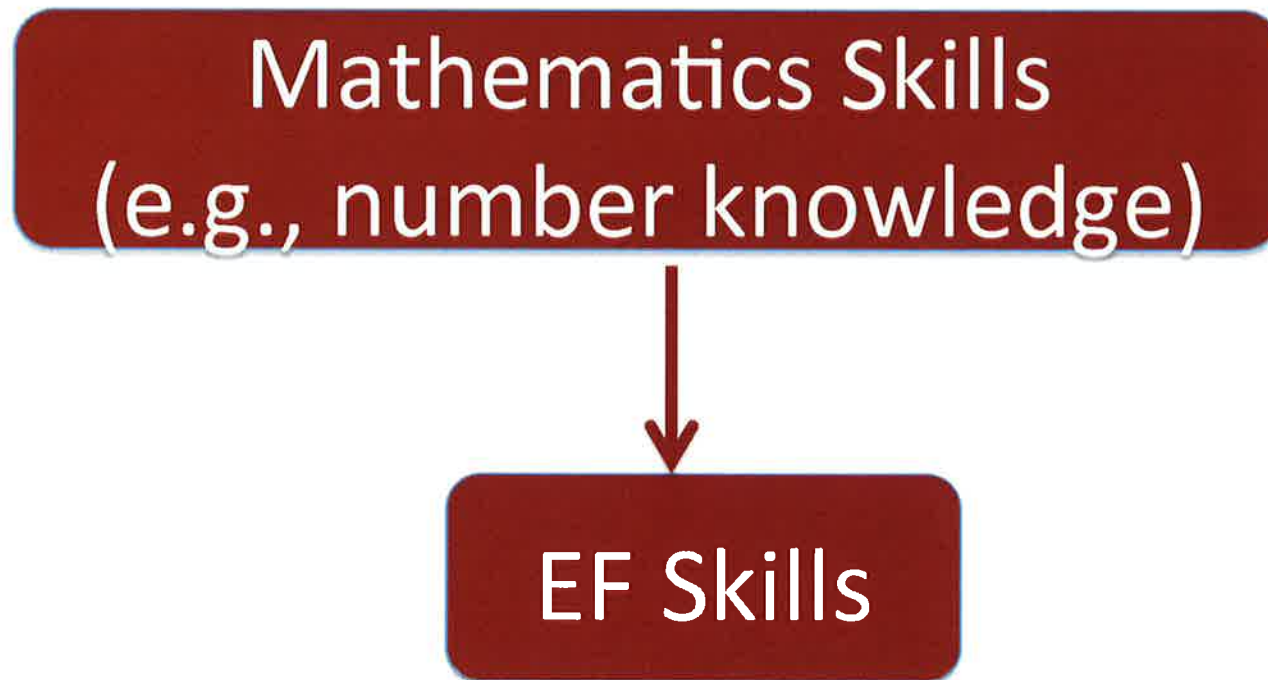
Mathematics



EF Skills

Executive function skills :

May be over taxed if number (and other math) skills are weak; so low math skills increase the EF demands of a difficult or novel math problem



Circle all pairs of numbers that

add up to **19**

Work as *quickly* as you can.

19

6th Graders

Composing and
Decomposing
Numbers Test
(CDNT)

60 sec limit

→ 12, 6 | 16, 3 | 5, 16 | 5, 14 | 13, 9 | 11, 4 | 11, 8

→ 5, 14 | 8, 7 | 12, 7 | 4, 14 | 13, 6 | 12, 11 | 14, 7

→ 2, 13 | 7, 12 | 6, 17 | 4, 15 | 8, 11 | 6, 15 | 5, 13

→ 15, 4 | 13, 8 | 6, 9 | 14, 5 | 3, 15 | 16, 3 | 7, 16

Mazzocco & Hanich, 2010

Circle all pairs of numbers that

add up to **19**

Work as *quickly* as you can.

19

Composing and
Decomposing
Numbers Test
(CDNT)

Pictured is the
“close foils”
subtest.

Sums = 19
Or $19 \pm 1-4$

60 sec limit

12, 6	16, 3	5, 16	5, 14	13, 9	11, 4	11, 8
-------	-------	-------	-------	-------	-------	-------

5, 14	8, 7	12, 7	4, 14	13, 6	12, 11	14, 7
-------	------	-------	-------	-------	--------	-------

2, 13	7, 12	6, 17	4, 15	8, 11	6, 15	5, 13
-------	-------	-------	-------	-------	-------	-------

15, 4	13, 8	6, 9	14, 5	3, 15	16, 3	7, 16
-------	-------	------	-------	-------	-------	-------

Circle all pairs of numbers that

add up to **19**

Work as *quickly* as you can.

19

Composing and
Decomposing
Numbers Test
(CDNT)

HITs + TN =
Correct/20

Misses
False Alarms =
Errors/29

60 sec limit

→	12, 6	16, 3	5, 16	5, 14	13, 9	11, 4	11, 8
---	-------	-------	-------	-------	-------	-------	-------

FA

M

→	5, 14	8, 7	12, 7	4, 14	13, 6	12, 11	14, 7
---	-------	------	-------	-------	-------	--------	-------

→	2, 13	7, 12	6, 17	4, 15	8, 11	6, 15	5, 13
---	-------	-------	-------	-------	-------	-------	-------

M

→	15, 4	13, 8	6, 9	14, 5	3, 15	16, 3	7, 16
---	-------	-------	------	-------	-------	-------	-------

M

From Mazocco & Hanich,
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Circle all pairs of numbers that

add up to **19**

Work as *quickly* as you can.

19



→ 21, 17 16, 3 25, 16 5, 14 13, 18 12, 19 11, 8

→ 5, 14 12, 26 12, 7 24, 14 13, 6 12, 11 14, 14

→ 2, 13 7, 12 6, 17 4, 15 8, 11 6, 15 5, 13

→ 15, 4 13, 8 6, 9 14, 5 3, 15 16, 3 7, 16

Composing and
Decomposing
Numbers Test
(CDNT)

“distant foils”
subtest.

Sums = 19
Or 19+/- 8+

60 sec limit

Circle all pairs of numbers that add up to 19
and cross out all pairs of numbers that add up to more than ~~23~~

Work as *quickly* as you can.

19

⇒ 15, 4 | 13, 8 | 6, 9 | 14, 5 | 3, 15 | 16, 3 | 8, 16

⇒ 12, 6 | 16, 3 | 5, 16 | 5, 14 | 15, 9 | 11, 4 | 11, 8
M

⇒ 6, 13 | 14, 5 | 2, 16 | 16, 8 | 7, 14 | 2, 17 | 3, 12
M

⇒ 9, 15 | 11, 7 | 15, 4 | 8, 13 | 9, 6 | 2, 17 | 3, 16

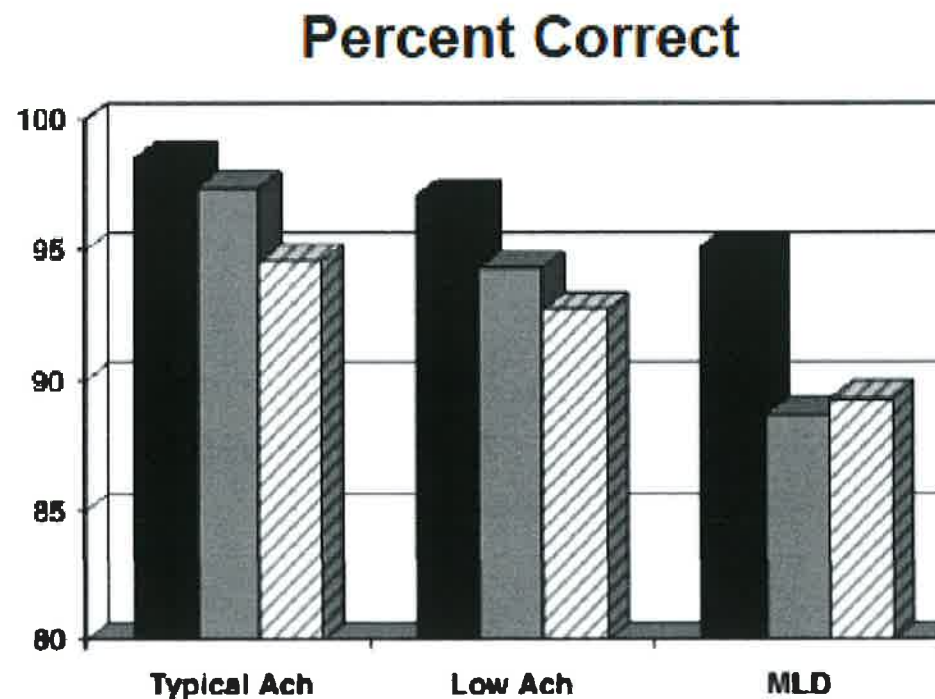
(CDNT)

Pictured is the
“interference
trial” subtest.

Sums = 19
Or 19+/- 8+
for 10 foils

60 sec limit

Middle school decomposition skills - poor numeracy mimics poor working memory?



■ Distant Foils

■ Close Foils

▨ Interference

Easiest

Hardest

Mazzocco & Hanich, 2010

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20 year old
Strong EF
Strong verbal
skills
Low math skills

Easy math
problem
requires a plan,
organization,
focus

32.

58

$$\begin{array}{r} 0.045 \\ \times 0.03 \\ \hline 0.135 \end{array}$$

0.00135

20 year old
Strong EF
Strong verbal
skills
Low math skills

Easy math
problem requires
a plan,
organization,
focus – Solving
for how many
rows of 5 is
needed to have a
set of 50 items

TEST 25
Applied Problems Worksheet



Figure from Mazzocco, 2009, *Developmental Disabilities Research Review*

11 year old
Poor number sense?
Poor EF?

In this case, poor math
skills increased EF
demands of the task

$$\begin{array}{r} 70 \\ 60 \\ 50 \\ 40 \\ 30 \\ 20 \\ 10 \\ 0 \end{array} \begin{array}{r} 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \end{array}$$

19

$$\begin{array}{r} 14 \\ \times 6 \\ \hline 84 \end{array}$$

Reading Problems Task

Age 10

9. $\begin{array}{r} 11 \\ 166 \\ +154 \\ \hline 320 \end{array}$	10. $\begin{array}{r} 09 \\ 17 \\ - 8 \\ \hline 11 \end{array}$	11. $\begin{array}{r} 4 \\ \times 5 \\ \hline 20 \end{array}$	12. $\begin{array}{r} 78 \\ 787 \\ - 19 \\ \hline 768 \end{array}$
13. $\begin{array}{r} 2 \\ 5 \overline{) 10} \end{array}$	14. $\begin{array}{r} 106 \\ + 362 \\ \hline 468 \end{array}$	15. $\begin{array}{r} 2 \\ \times 8 \\ \hline 16 \end{array}$	16. $\begin{array}{r} 4 \\ 2 \overline{) 10} \end{array}$

Tens / ones

$$\begin{array}{r|l} 15 & 4 \\ + & 60 \\ \hline 130 & 0 \end{array}$$

130

XXXXXXXXXXXXX

XXXXXX
XXXXXX



Which one of these tools shows more water in the tank

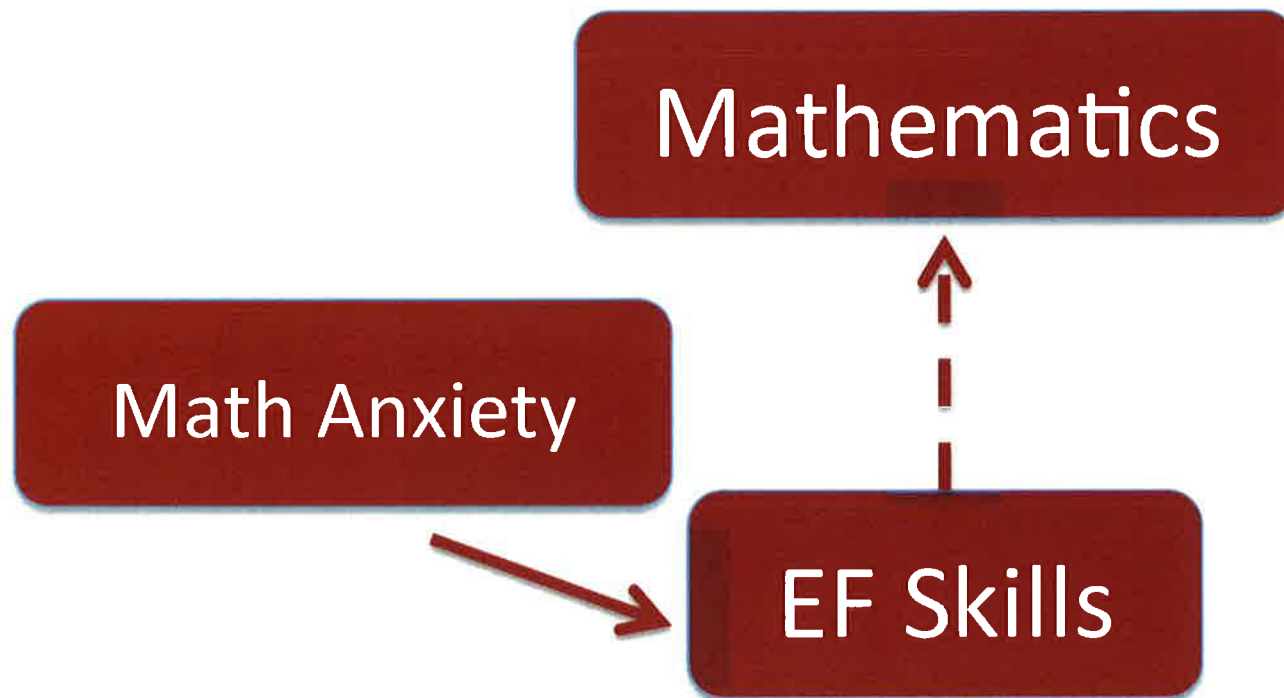


Context does make math more meaningful.

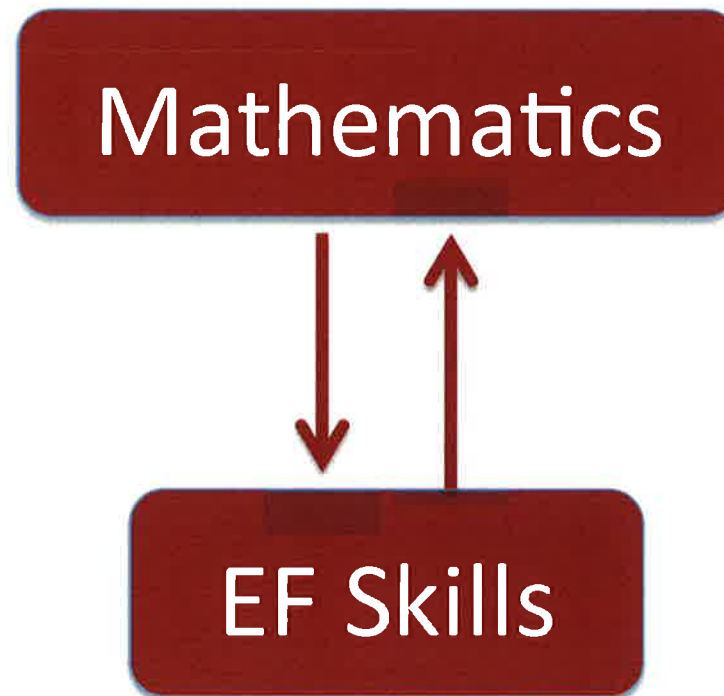


But overloading instructions on how to do a task may increase the EF demands (and difficulty) of a task

Executive function skills :
may be drained or overtaxed by math anxiety,
and less available to support mathematics



Executive function and math skills :
Promote development of each other



Magician's Tricks



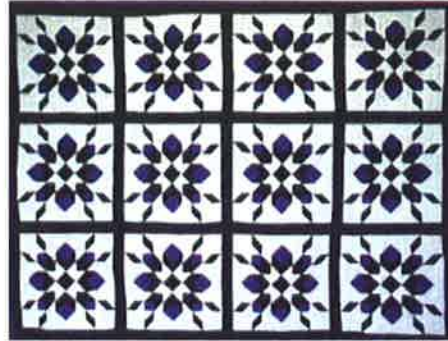
- Activity Goals:
 - Teach number order, counting on, number relations
 - Support working memory and self reflection development
- Activity Steps:
 - Number cards placed in numerical order (then flipped)
 - Point to cards and guess number
 - Point to cards and keep guessed cards flipped (relational terms)

DREME Network Research Study

Magician's Tricks Challenge Strategy Examples

	Decreasing Demands	Increasing Demands
Math	<p>Explicit review of basic counting</p> <p>Encourage use of fingers when counting</p>	<p>Encourage counting backward with high cards (6-10)</p> <p>Use more counting cards (up to 12 or 20, instead of 1-10)</p>
EF	<p>Use fewer counting cards (1-5)</p> <p>Display second set of cards above flipped set</p>	<p>Put cards in 2 or 4 rows, instead of 1 row</p> <p>Cover beginning cards (1-5)</p>

DREME Network Research Study



SUMMARY - Mathematics and EF

Executive function skills :

- promote *doing* math (building proficiency)
- promote *learning* math
- may be over-taxed by math anxiety / stereotype threat, but...
may be used to override the interfering thoughts
- mediate development of early numerical (spatial) thinking
- may benefit from quality mathematics activities