IS METACOGNITION DOMAIN-SPECIFIC OR DOMAIN-GENERAL?

INSIGH FROM STUDIES IN MEMORY AND ARITHMETIC

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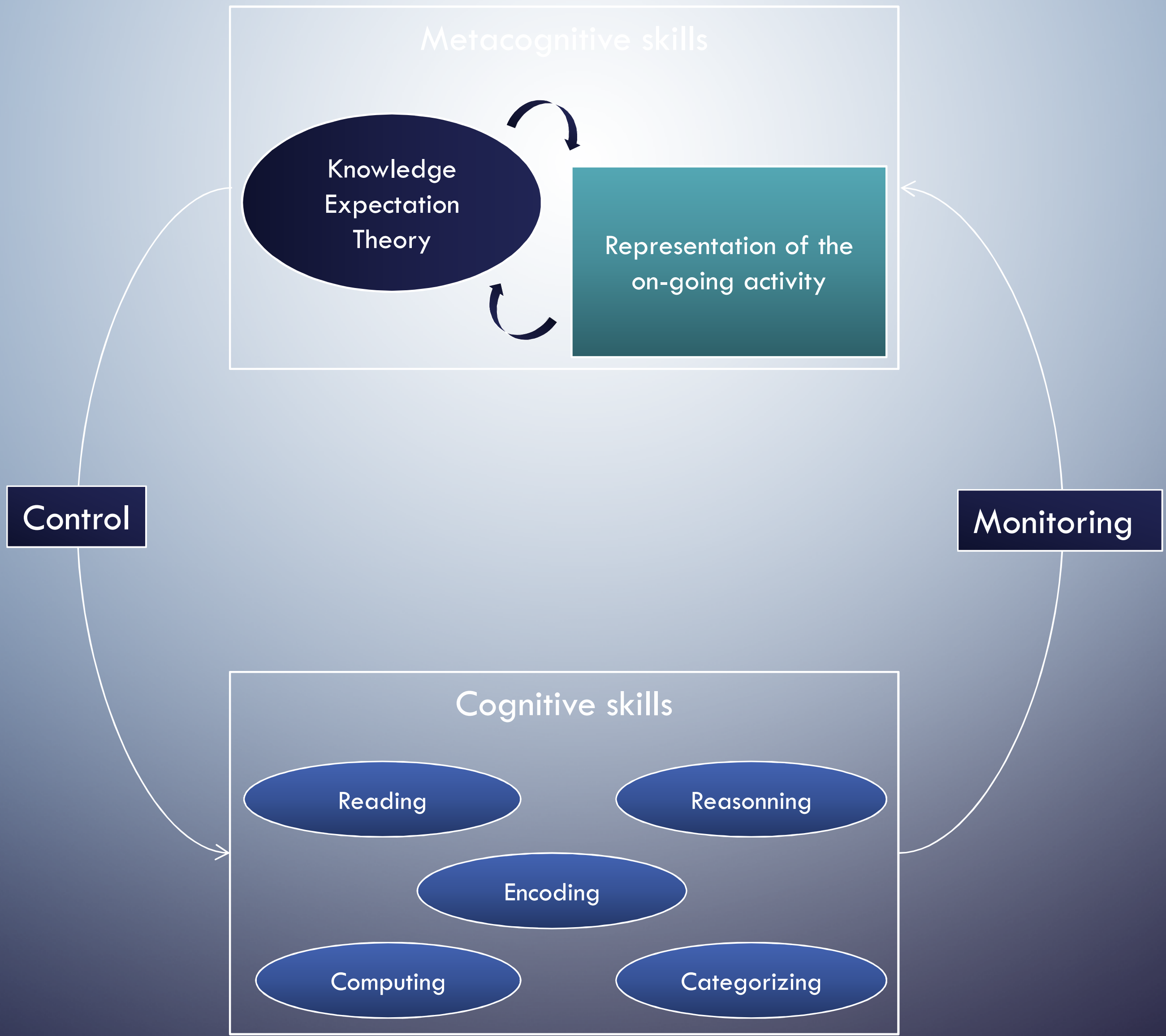
Metacognitive skills
Knowledge
Expectation
Theory
Representation of the on-going activity
Control
Monitoring
Cognitive skills
Reading
Reasonning
Encoding
Computing
Categorizing

BACKGROUND

- To date, very few studies have explored whether metacognitive processes are involved in how participants select and execute strategies
- Being able to accuratly decide whether a selected strategy is the best to solve a problem allows:
  - To switch from a poorer to a better strategy, possibly improving cognitive performance
  - To learn what strategy is useful in specific contexts

  ➔ Investing limited resources in areas that yield optimal return

BACKGROUND

- Examining whether people can make accurate metacognitive judgments on strategy selection
- Determining whether there is age-related differences in the accuracy of these judgments
  - Inconsistent results in previous studies

BACKGROUND

Stability

- Less resource-consuming tasks

Change

- More resource-consuming tasks
- Conducted in the memory domain

The accuracy at the metacognitive level depends on the accuracy at the cognitive level

➔ Examining age-related differences in metacognitive abilities in a cognitive domain where older adults are not put at a disadvantage as compared to young adults

AIMS

- Arithmetic is a domain where older and young adults have similar performances
  - Determining whether people can accuratly judge whether they had selected the best strategy to solve an arithmetic problem
  - Examining whether there is age-related differences in the accuracy of metacognitive judgments for strategy selection
  - Exploring whether (a) the accuracy of metacognitive judgments and (b) age-related differences in the accuracy of metacognitive judgments depend on task characterictics (i.e., amount of cognitive resources required to solve the task)

Geurten M., & Lemaire, P. (2018). Metacognition for strategy selection during arithmetic problem-solving in young and older adults. *Aging, Neuropsychology and Cognition*. doi:10.1080/13825585.2018.1464114

METHODS

Participants

- 37 young adults (29 females; mean age = 21.14 years; age range = 18-29)
- 29 older adults (18 females; mean age = 72.99 years; age range = 64-88)

Stimuli

- 32 multiplication problems (a x b) – 16 homogeneous (21 x 32) VS. 16 heterogeneous (49 x 24) problems
- Half of the problems were better solved by rounding both operands up (39 x 48) – rounding-up problems
- Half of the problems were better solved by rounding both operands down (21 x 32) – rounding-down problems
- Participants had to select the best strategy to solve each problem between the two available strategies

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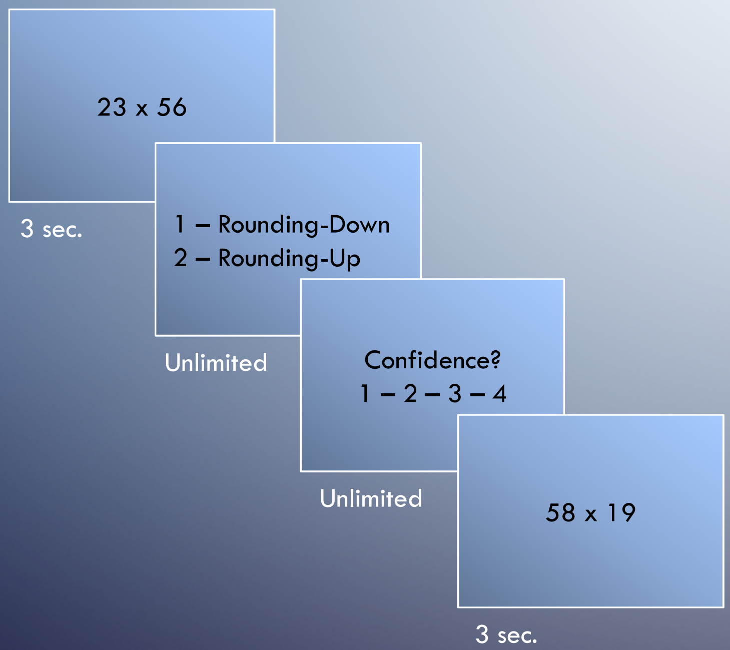
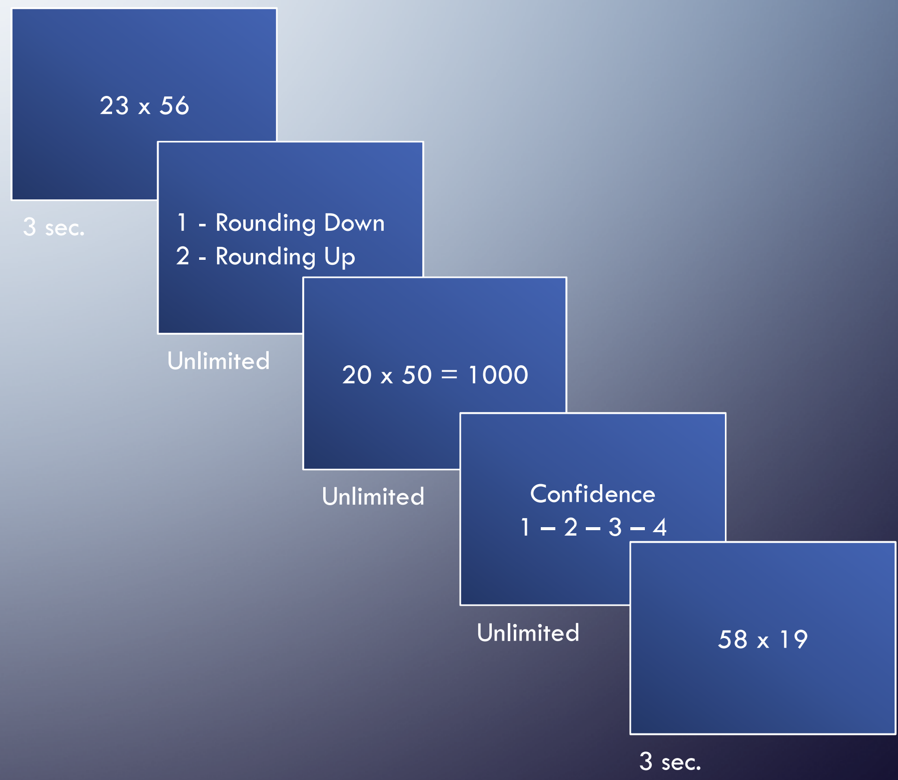
METHODS

SELECTION-ONLY TASK



SELECTION-EXECUTION TASK



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MEASURES

- Measures of metacognitive accuracy
  - A'ROC = A non-parametric measure from signal detection theory which plots the concordances (i.e., a higher judgment on correct better strategy selection or a lower judgment on incorrect better strategy selection) against the discordances (i.e., a higher judgment on incorrect better strategy selection or a lower judgment on correct better strategy selection)
  - An A'ROC of 0.5 (or lower) indicated no metacognitive discrimination between better or poorer strategy selections

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RESULTS

ABOVE CHANCE METACOGNITIVE ACCURACY

	Mean (SD)	t
Selection-Execution Task		
Young adults (N=37)	.60 (.02)	6.23**
Older adults (N=29)	.60 (.02)	3.66*
All (N=66)	.60 (.02)	6.71**
Selection-Only Task		
Young adults (N=37)	.63 (.02)	6.46**
Older adults (N=29)	.72 (.02)	8.52**
All (N=66)	.67 (.02)	10.03**

*p < .05; **p < .001

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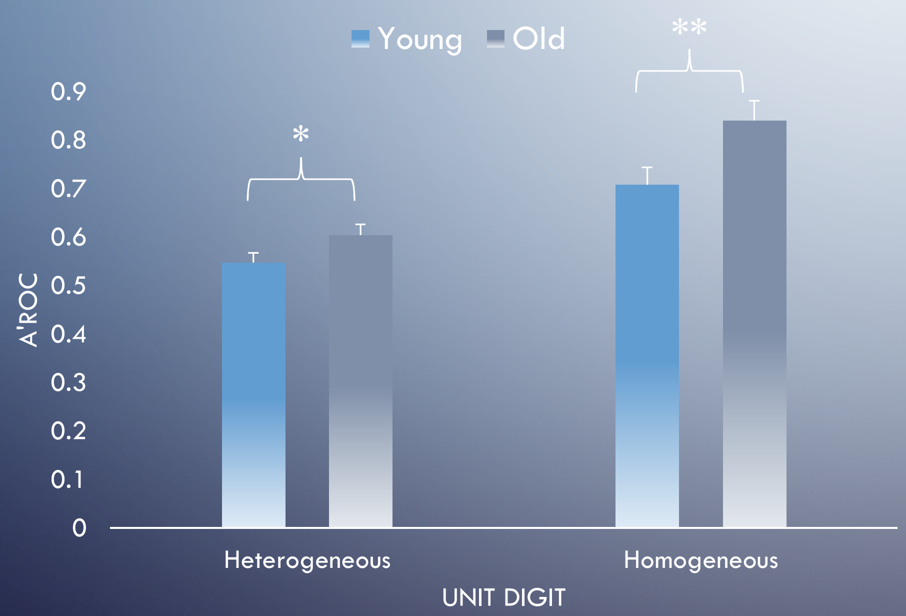
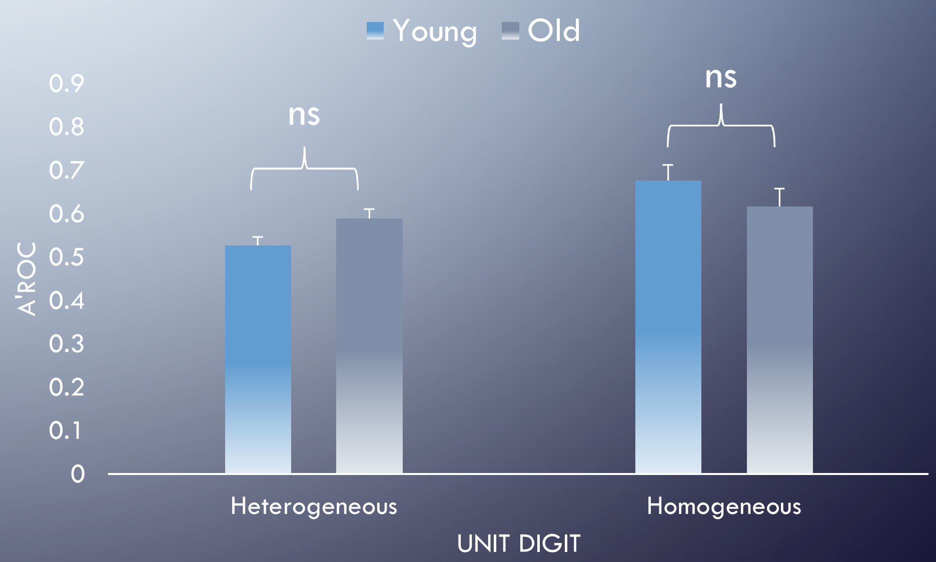
RESULTS

AGE-RELATED AND TASK-RELATED DIFFERENCES IN METACOGNITIVE ACCURACY

SELECTION-ONLY TASK



SELECTION-EXECUTION TASK



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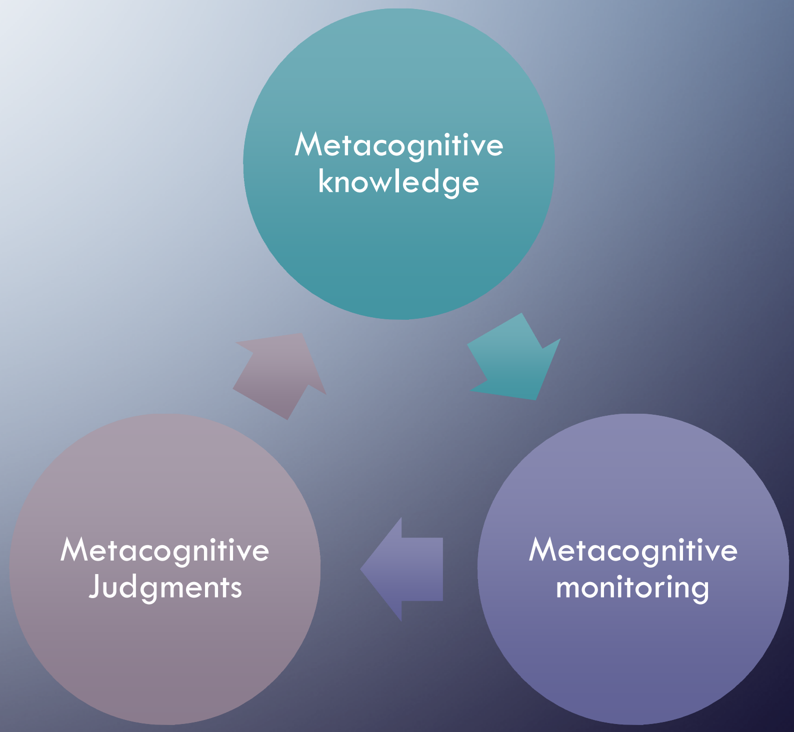
CONCLUSION

- Participants made accurate (above chance) metacognitive judgments for strategy selection
- Participants' age and tasks' characteristics affect the accuracy of these judgments
  - Only the accuracy of older adults judgments is reduced when judgments are made on the more resource-consuming tasks (selection-execution task)

  → Limited resources in older adults

  - Older adults made more accurate judgments than young adults on the less resource-consuming task (selection only task)

  → Better metacognitive knowledge



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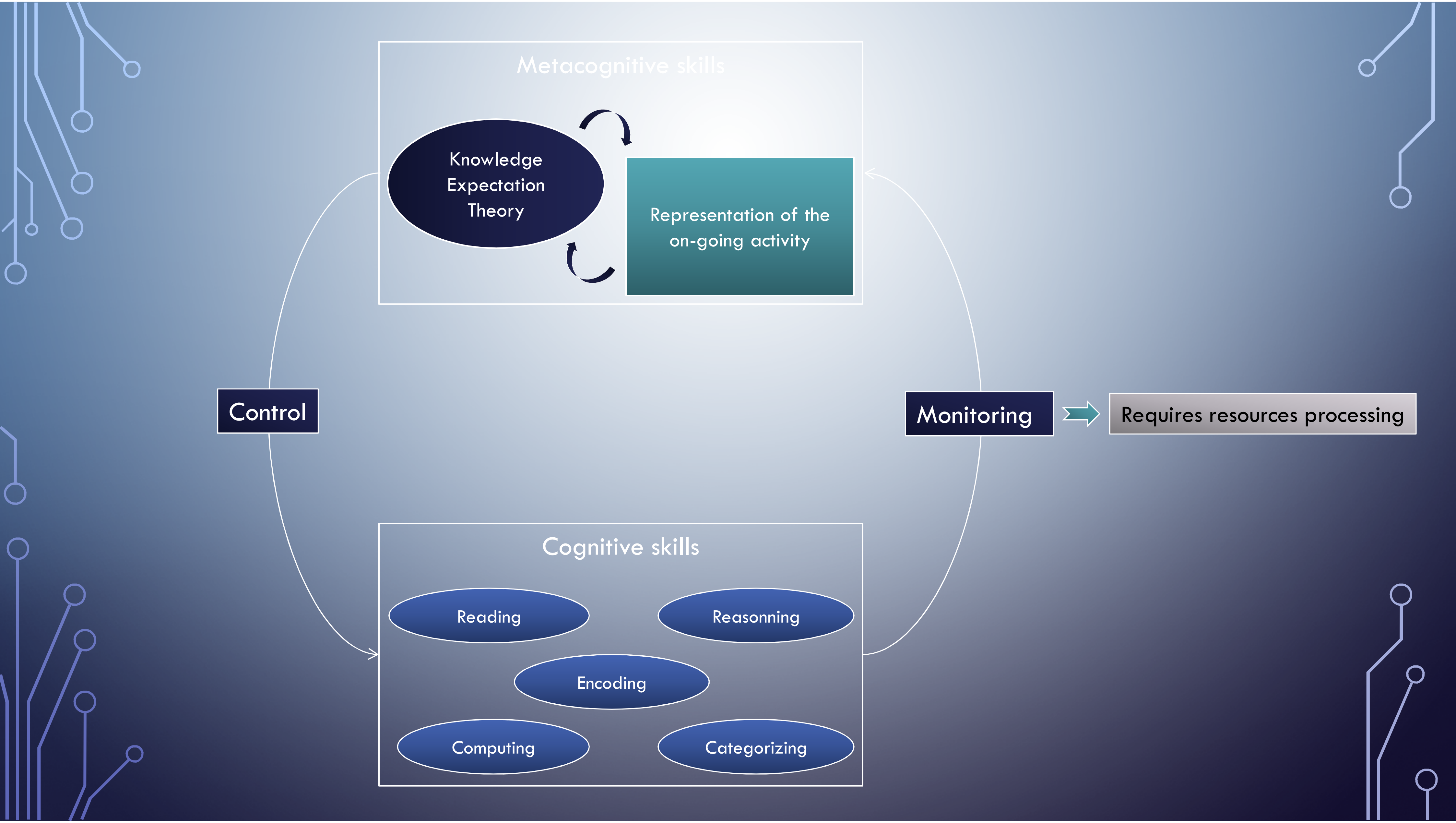
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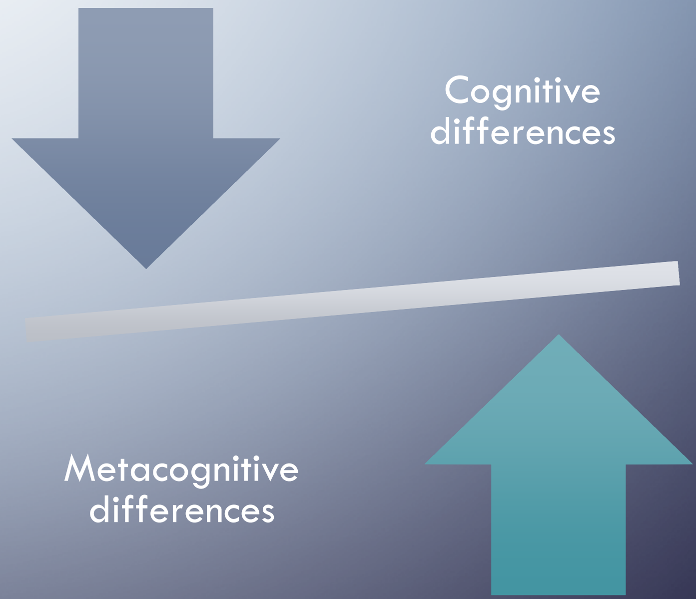
BACKGROUND

- Results of our study focusing on age-related differences in metacognition for arithmetic problem solving are quite at odds with the results of studies conducted in the memory domain

→ Differences at the cognitive level ?

→ Metacognition is domain-specific ?



BACKGROUND

- In adults, the assumption that metacognition is domain-general is supported by two types of evidence:
  - Behavioral studies: measures of metacognitive sensitivity correlated across unrelated cognitive tasks
  - Imaging data: metacognitive abilities for different types of tasks partially depend on common neural structures
- In children, available data sets suggest that metacognition could be domain-specific in early development
  - Vo et al. (2014): 5- to 8-year-olds' metacognition for a numerical discrimination task was unrelated to their metacognition for an emotion discrimination task
- Generalization of metacognitive abilities across domains as children mature ?

AIM

- The primary goal of this study was to:
  - Document the developmental course of domain-generality/-specificity of metacognition for strategy selection in both the arithmetic and the memory domains

    ➔ monitoring the accuracy of strategy selection could involve more global metacognitive skills than monitoring cognitive performance, increasing our chances of showing a generalization of metacognitive processes

METHODS

Participants

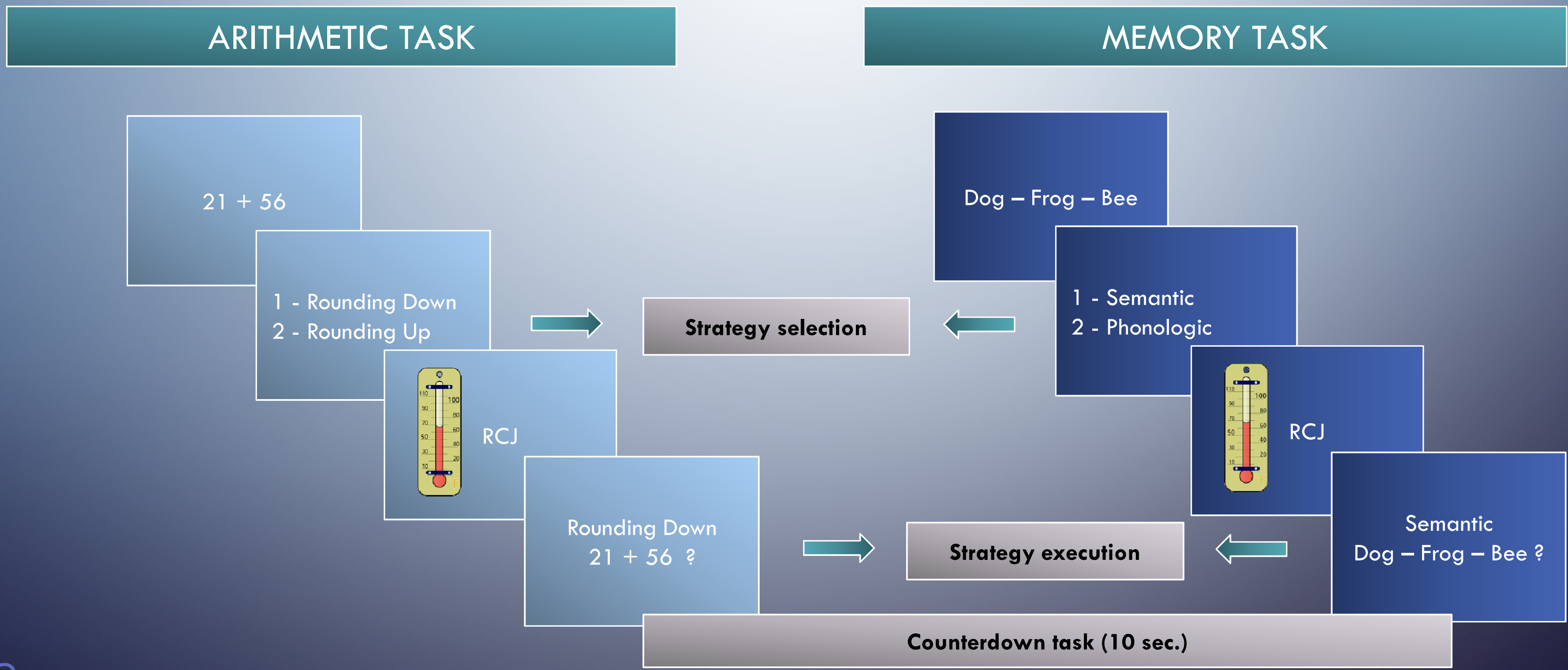
- 24 typically developing children aged 8-9 years (13 girls; mean age = 9.25 years; SD = 0.48)
- 24 typically developing children aged 10-11 years (13 girls; mean age = 11.19 years; SD = 0.43)
- 24 typically developing children aged 12-13 years (16 girls; mean age = 12.79 years; SD = 0.60)

Stimuli

- 32 addition problems – 16 rounding-down (21 + 32) VS. 16 rounding-up (49 + 26) problems
- 32 triads of words – 16 phonologic (Bat – Cat – Hat) VS. 16 semantic (Dog – Frog – Bee) triads
- Participants had to select the best strategy to solve each problem between the two available strategies

Geurten M., Meulemans, T., & Lemaire, P. (submitted). From domain-specific to domain-general? The developmental path of metacognition for strategy selection. *Cognitive Development*.

METHODS



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MEASURES

- We computed three measures of metacognition for each strategy selection tasks: ϕ, γ, and A'_{ROC}
  - They all represent the relation between selection accuracy and metacognitive judgments
  - The ϕ and γ coefficients are popular measures of metacognitive sensitivity and provide a common scale to compare our results to those of previous studies examining the domain-generality of metacognition
  - The A'_{ROC} index provides a bias-free measure of metacognition

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RESULTS

ABOVE CHANCE METACOGNITIVE ACCURACY

	φ		γ		A'_{ROC}	
	M	t	M	t	M	t
Arithmetic						
8-9 year olds	.25	4.33**	.35	2.49*	.60	3.83**
10-11 year olds	.23	6.48**	.28	1.89*	.62	6.25**
12-13 year olds	.39	7.23**	.45	3.59*	.70	5.64**
Memory						
8-9 year olds	.24	5.24**	.39	3.24*	.58	3.83**
10-11 year olds	.31	5.33**	.46	4.06**	.66	4.60**
12-13 year olds	.37	8.48**	.42	2.63*	.66	5.62**

Note. Comparisons against chance: i.e., 0 for φ and γ; 0.5 for Area under the Receiver-Operating-Characteristic (ROC) curve (A'_{ROC}).
**p*<.05; ***p*<.001

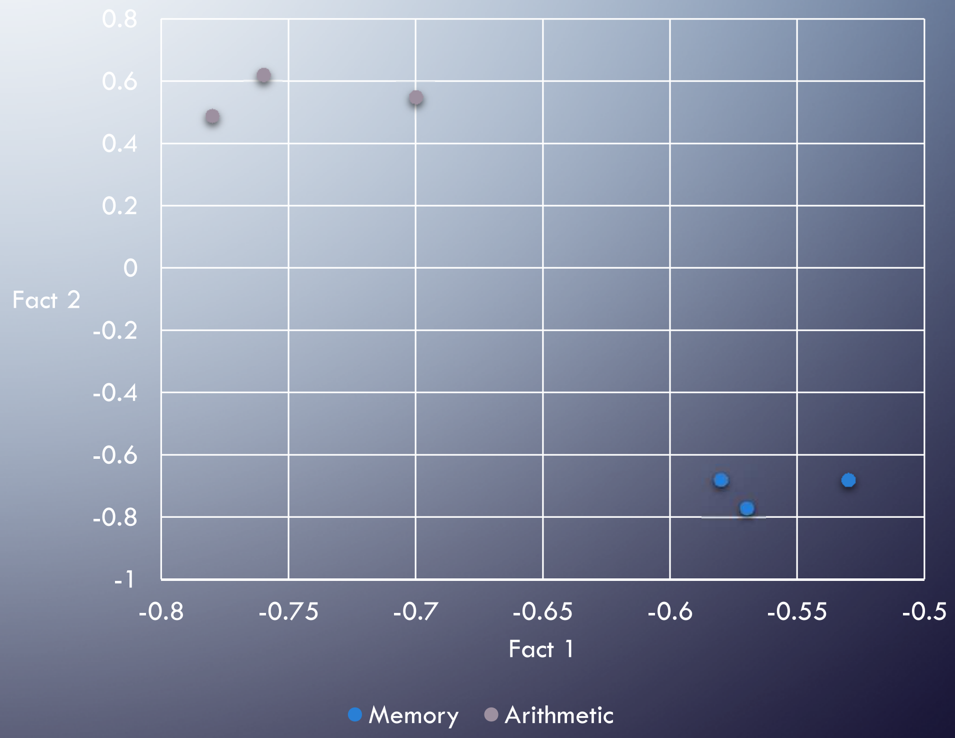
Geurten M., Meulemans, T., & Lemaire, P. (submitted). From domain-specific to domain-general? The developmental path of metacognition for strategy selection. *Cognitive Development*.

RESULTS

DOMAIN-SPECIFICITY/-GENERALITY OF METACOGNITION

8-9 years		Factor 1	Factor 2
Arithmetic	Phi	-.76	.62
	Gamma	-.70	.55
	A'_{ROC}	-.78	.49
Memory	Phi	-.58	-.68
	Gamma	-.57	-.77
	A'_{ROC}	-.53	-.68
% explained variance		53%	37%

$R_{Canon} = .53$
$\chi^2(9) = 9.11$ p = .43

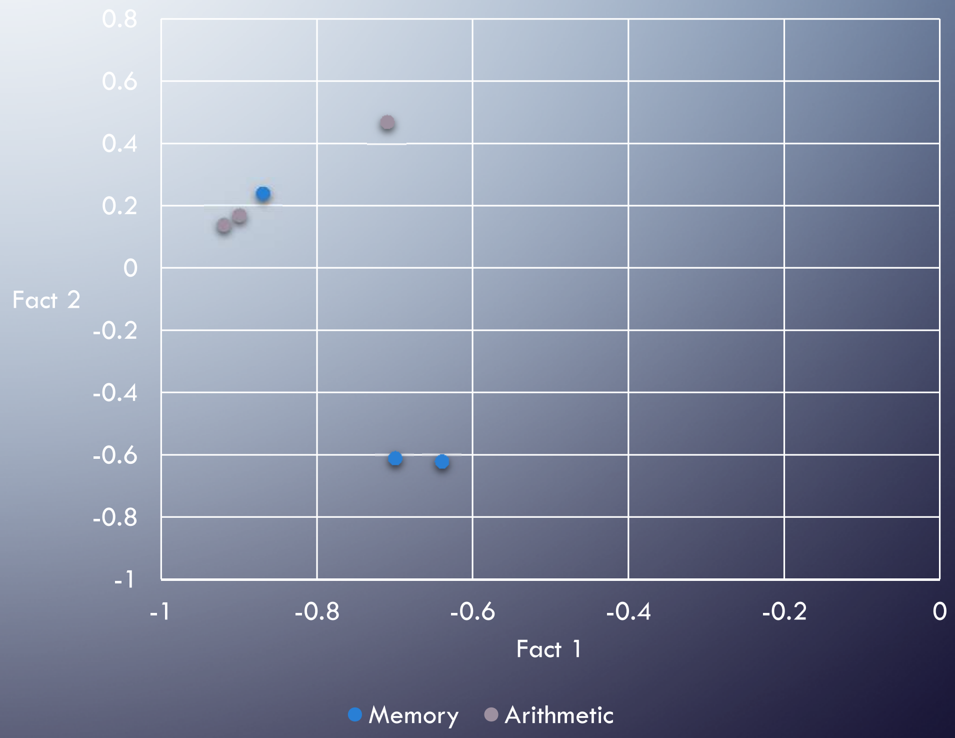


RESULTS

DOMAIN-SPECIFICITY/-GENERALITY OF METACOGNITION

10-11 years		Factor 1	Factor 2
Arithmetic	Phi	-.90	.17
	Gamma	-.92	.14
	A'_{ROC}	-.71	.47
Memory	Phi	-.70	-.61
	Gamma	-.64	-.62
	A'_{ROC}	-.87	.24
% explained variance		61%	20%

$R_{Canon} = .85$
$\chi^2(9) = 31.92$ $p < .001$



RESULTS

DOMAIN-SPECIFICITY/-GENERALITY OF METACOGNITION

12-13 years		Factor 1
Arithmetic	Phi	-.91
	Gamma	-.87
	A'_{ROC}	-.95
Memory	Phi	-.94
	Gamma	-.83
	A'_{ROC}	-.84
% explained variance		80%

$R_{Canon} = .86$
$\chi^2(9) = 31.96$ $p < .001$

CONCLUSION

- Our results indicated a gradual shift toward domain-general metacognition in children aged between 8 and 13

  ➔ Metacognition is first domain-specific, and then seems to generalize across domains as children mature

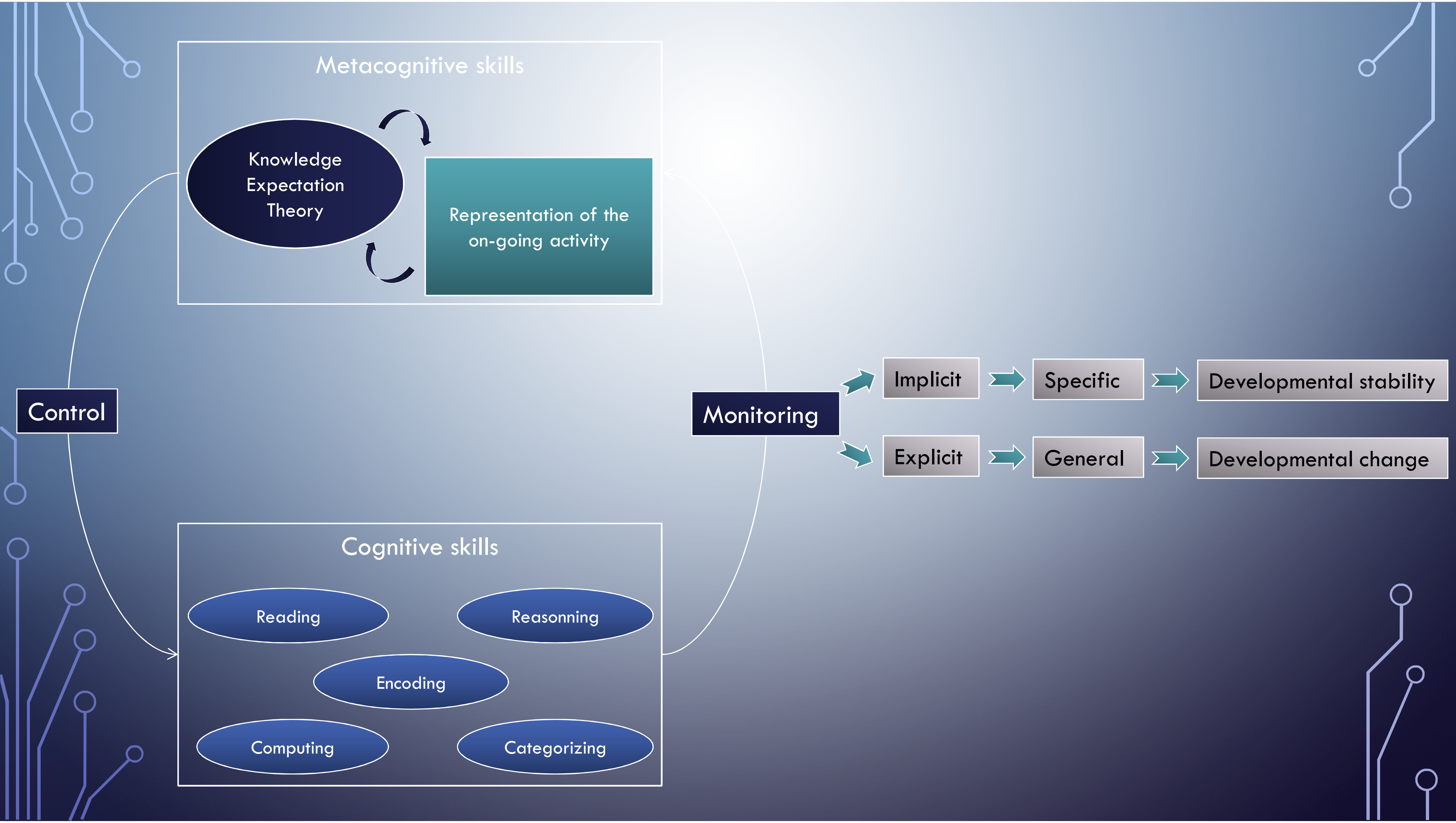
- Clinical perspective
  - Major impact on metacognitive revalidation programs
  - If metacognition does not depend on domains, it implies that metacognitive interventions in one domain could have positive effects across all domains.

CONCLUSION

GENERALIZATION. BUT OF WHAT?

CONCLUSION

- According to the dual-process framework of metacognition (Koriat, 2007), two mechanisms come into play when people have to distinguish what they know from what they do not know:
  - Experience-based judgments = fast and automatic inferences made from a variety of cues (e.g., processing fluency) that are heuristically used to guide decisions.
    - → Based on cues that reside from the immediate feedback from the task
    - → Task-dependent
    - → Difficult to generalize across domains.
  - Information-based judgments = conscious and deliberate inferences, in which various pieces of information retrieved from memory are consulted and weighted in order to reach an educated judgment.
    - → Conscious and effortful processes
    - → More likely to be generalized to other domains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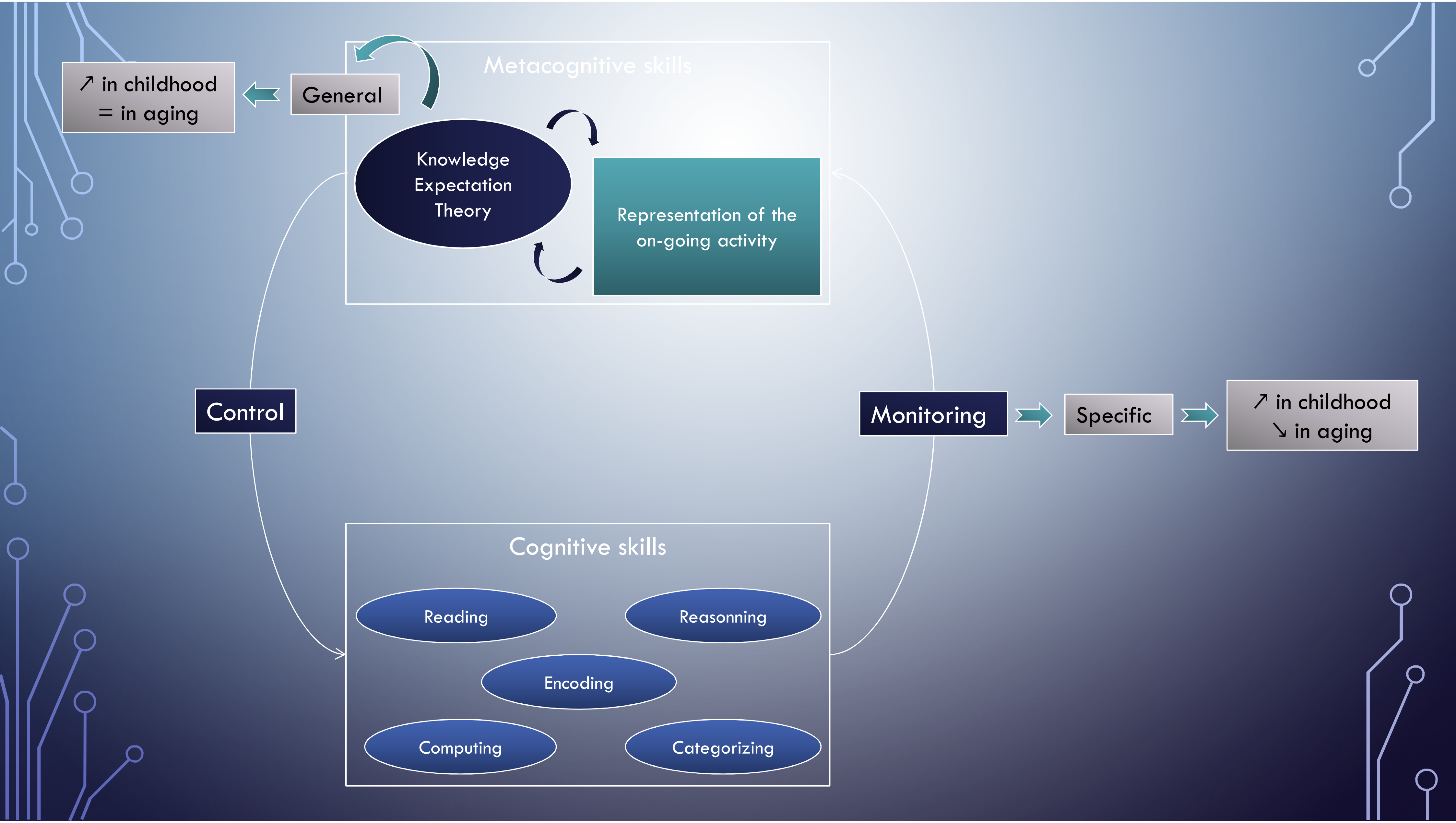
↗ in childhood
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General
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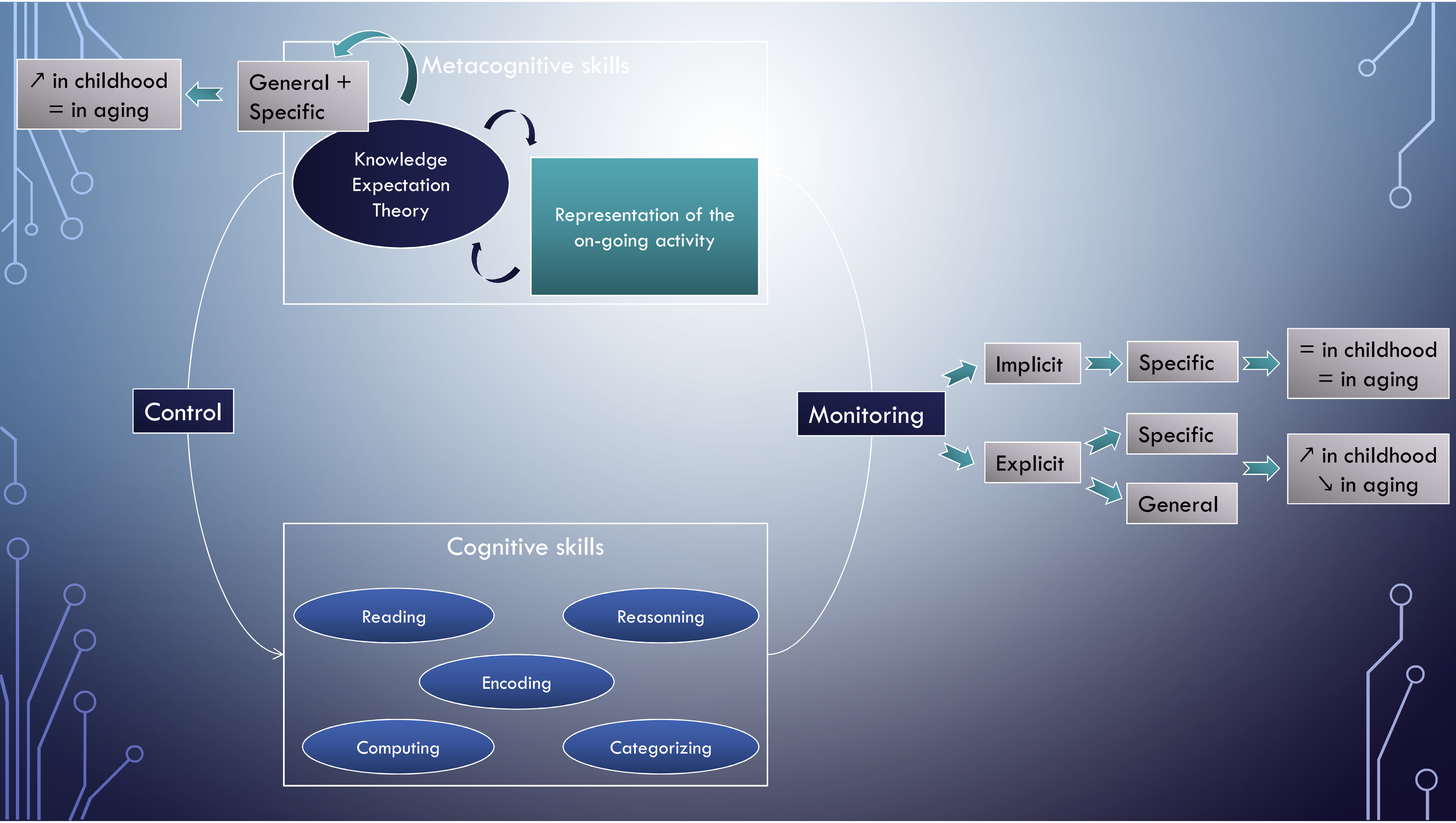
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THANKS FOR YOUR ATTENTION

Any questions ?