Metacognitive processing in early childhood.

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Theoretical background

-Metacognition refers to the ability of an individual to reflect on their own cognition and behaviour [1].

-Metacognition has been suggested to develop with age [2] and has been considered a fundamental ability for students' academic achievement in various domains [3].

-Research suggests that, during early childhood, a gradual shift from domain-specific to domain-general mechanisms supporting metacognitive processing occurs [4].

-However, up-to-date research in the development of metacognition is mainly based on self-report questionnaires and there is a lack of robust metrics of metacognition that can be comparable across tasks.


Meta-level or type-2 performance

monitor — control

Object-level or type-1 performance
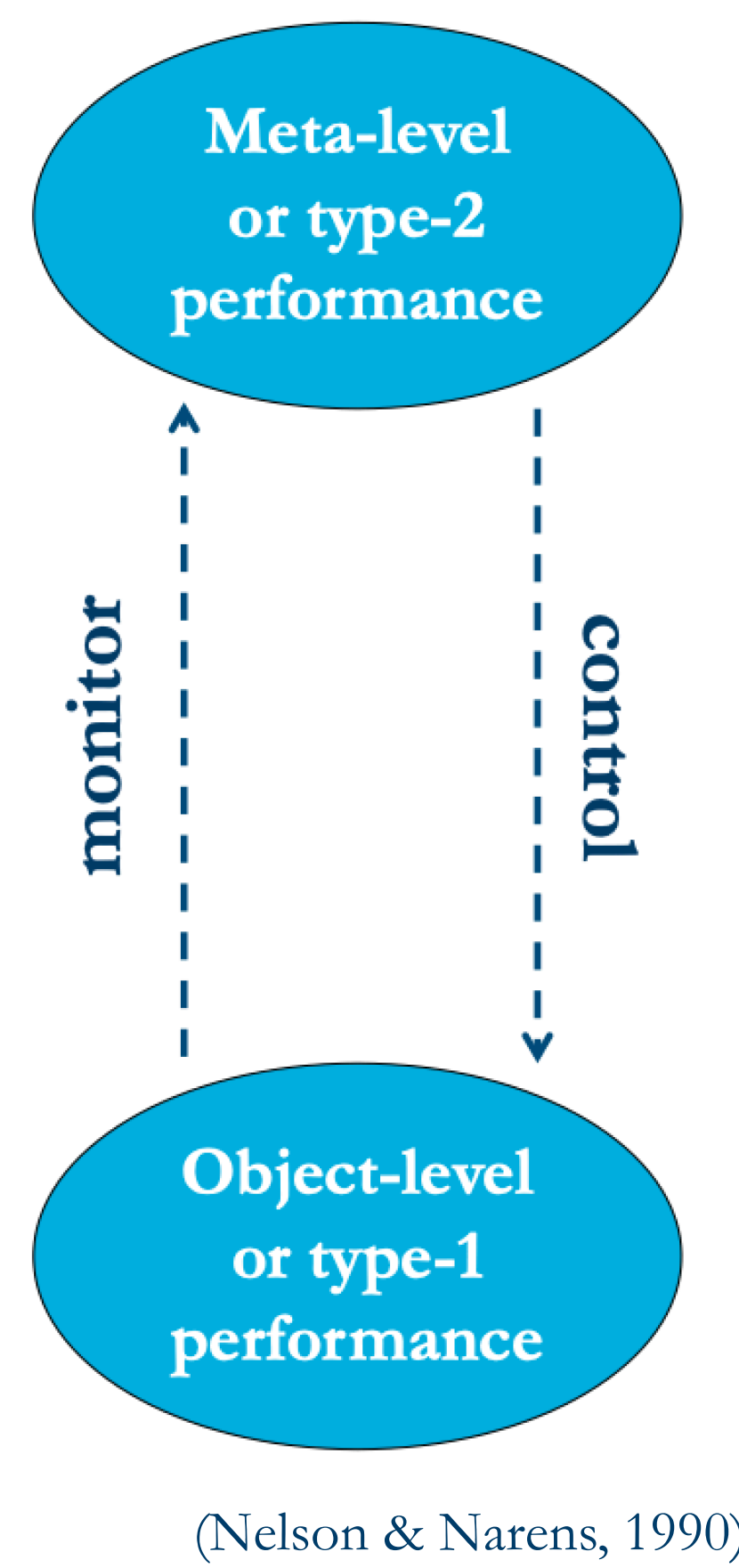
(Nelson & Narens, 1990)

The present study

-We evaluated the metacognitive ability of a cohort of children aged between 6 and 7 (N=60) in three cognitive tasks: a. **Lexical decision**: words vs pseudowords, b. **Emotion recognition**: happy vs neutral face, c. **Visual attention span**: detect the presence of a letter in a letter array, using confidence judgments in each trial (see figures).

-We used a Bayesian framework [5] to estimate type-1 task performance (d' prime) and type-2 performance (metacognitive efficiency - meta-d'/d').
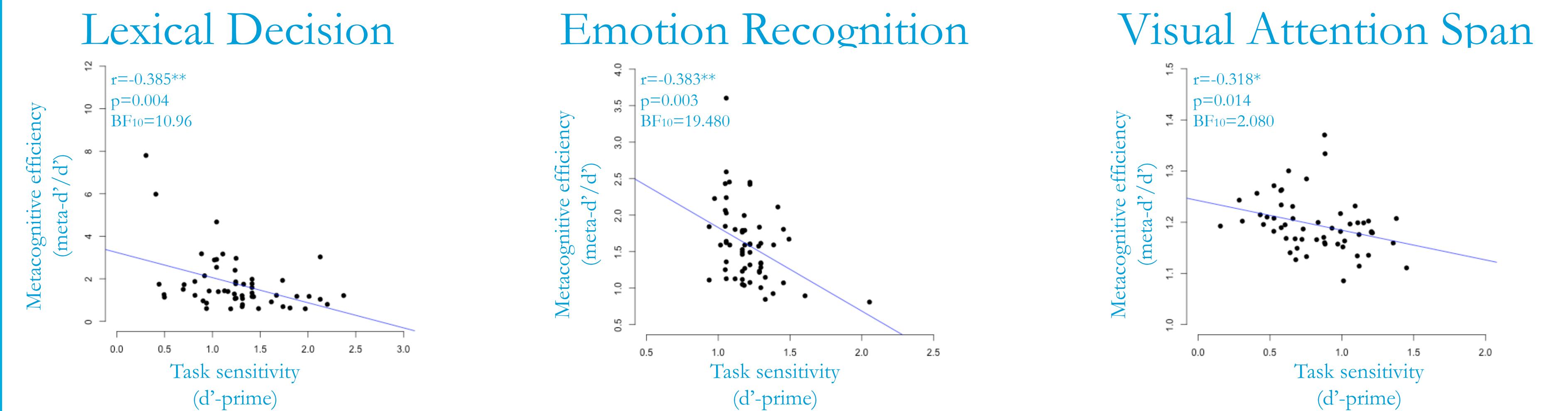
Research questions:

1. **Does metacognitive ability of children correlate with their objective performance in the cognitive tasks?**
2. **Is metacognitive ability supported by the same mechanisms across the different tasks?**
3. **Is metacognition related to general cognitive ability during development?**

Lexical Decision task structure

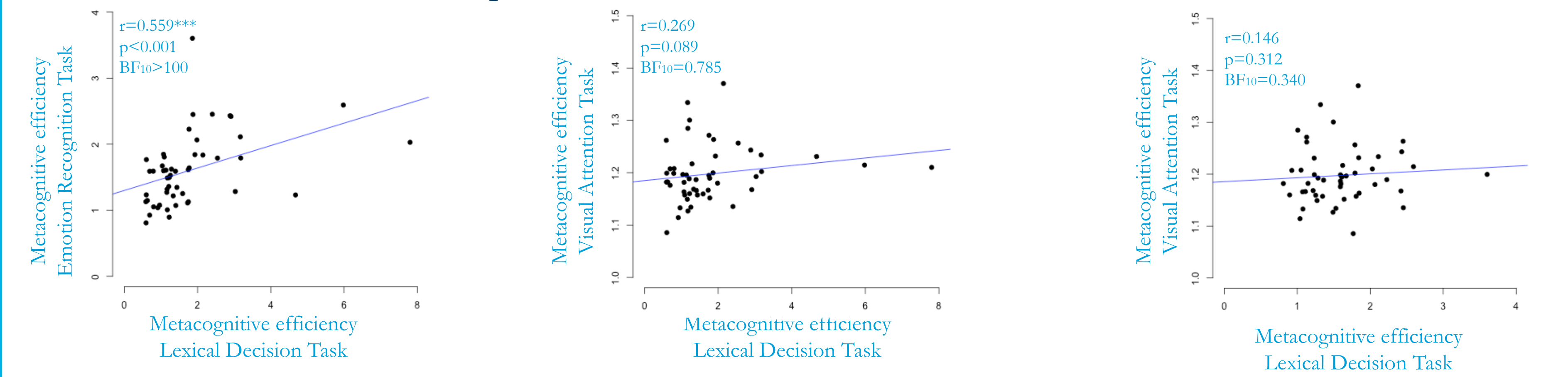Emotion Recognition task structure
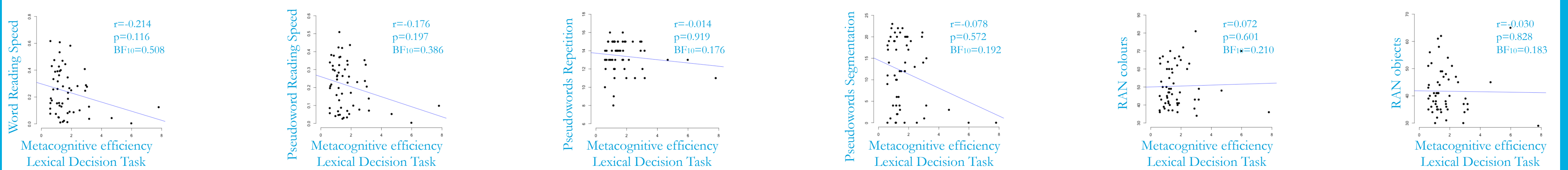
Visual Attention Span task structure
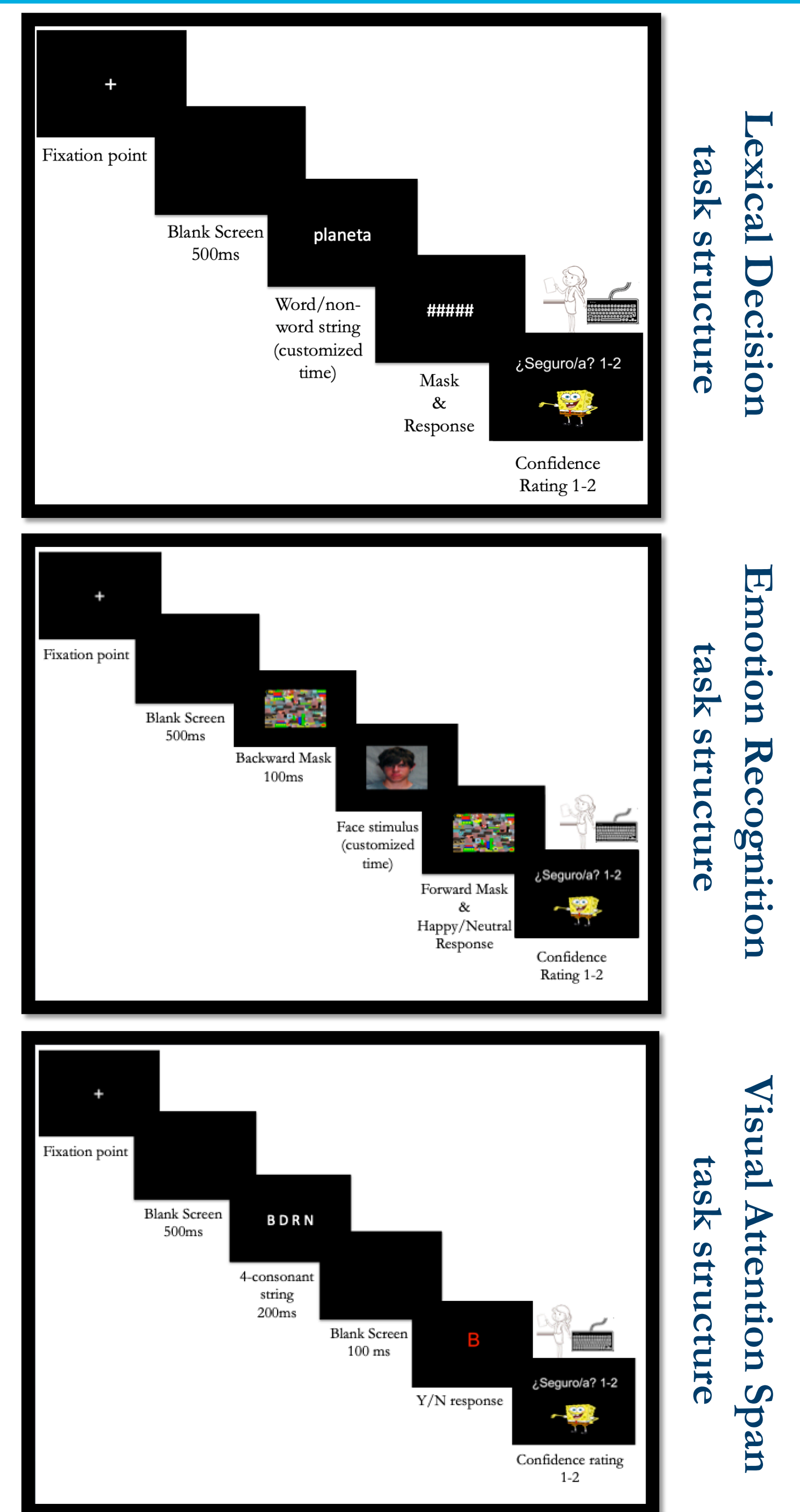
Main findings

(i) Type-1 performance across the three cognitive tasks negatively correlated with the level of metacognitive efficiency (HMeta-d/Hd) across participants.

Lexical Decision

r=-0.385**
p=0.004
BF10=10.96

Metacognitive efficiency (meta-d'/d') vs Task sensitivity (d'-prime)

Emotion Recognition

r=-0.383**
p=0.003
BF10=19.480

Metacognitive efficiency (meta-d'/d') vs Task sensitivity (d'-prime)

Visual Attention Span

r=-0.318*
p=0.014
BF10=2.080

Metacognitive efficiency (meta-d'/d') vs Task sensitivity (d'-prime)

(ii) Metacognitive efficiency on the lexical decision positively correlated with the emotion recognition task, in keeping with a model of a domain-general metacognitive mechanism. This however was not borne out by the data from the visual attention span task.

r=0.559***
p<0.001
BF10>100

Metacognitive efficiency Emotion Recognition Task vs Metacognitive efficiency Lexical Decision Task

r=0.269
p=0.089
BF10=0.785

Metacognitive efficiency Visual Attention Task vs Metacognitive efficiency Lexical Decision Task

r=0.146
p=0.312
BF10=0.340

Metacognitive efficiency Visual Attention Task vs Metacognitive efficiency Lexical Decision Task

(iii) No evidence of associations between students' metacognitive efficiency on the three cognitive tasks and any of the standardized general ability tasks was found.

r=-0.214 p=0.116 BF10=0.508 — Word Reading Speed vs Metacognitive efficiency Lexical Decision Task

r=-0.176 p=0.197 BF10=0.386 — Pseudoword Reading Speed vs Metacognitive efficiency Lexical Decision Task

r=-0.014 p=0.919 BF10=0.176 — Pseudowords Repetition vs Metacognitive efficiency Lexical Decision Task

r=-0.078 p=0.572 BF10=0.192 — Pseudowords Segmentation vs Metacognitive efficiency Lexical Decision Task

r=0.072 p=0.601 BF10=0.210 — RAN colours vs Metacognitive efficiency Lexical Decision Task

r=0.030 p=0.828 BF10=0.183 — RAN objects vs Metacognitive efficiency Lexical Decision Task

Discussion

- Our results suggest that at this early age **students who perform worse in the tasks have better metacognitive efficiency**. This may have implications for developing educational interventions.

-Our study also indicates the **existence of a domain-general resource supporting metacognition** in lexical decision and emotion recognition task. The absence of association between metacognitive performance in the visual attention task and any other task could be due to differences in task structure, (i.e. 2AFC vs. detection in the attention span task) [7].

References:

[1]Nelson, T. O. (1990). Metamemory: A Theoretical Framework and New Findings. In *Psychology of Learning and Motivation* (pp. 125–173).

[2]Weil, L. G., Fleming, S. M., Dumontheil, I., Kilford, E. J., Weil, R. S., Rees, G., Dolan, R. J., & Blakemore, S.-J. (2013). The development of metacognitive ability in adolescence. *Consciousness and Cognition*, 22(1), 264–271

[3]Bellon, E., Fias, W., & De Smedt, B. (2019). More than number sense: The additional role of executive functions and metacognition in arithmetic. *Journal of Experimental Child Psychology, 182*, 38–60

[4]Geurten, M., Meulemans, T., & Lemaire, P. (2018). From domain-specific to domain-general? The developmental path of metacognition for strategy selection. In *Cognitive Development* (Vol. 48, pp. 62–81)

[5]Fleming, S. M. (2017). HMeta-d: hierarchical Bayesian estimation of metacognitive efficiency from confidence ratings. *Neuroscience of Consciousness*, 2017(1), 1-14

[6]Rahnev, D., Desender, K., Lee, A.L.F. et al. (2020). The Confidence Database. *Nature Human Behaviour*, 4, 317–325

7 Ruby, E., Giles, N., & Lau, H. (2017). Finding domain-general metacognitive mechanisms requires using appropriate tasks, Preprint, bioRχiv