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Developmental interconnections between ToM and metacognition. The role of executive functions and language

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H.F.R.I. Hellenic Foundation for Research & Innovation

*The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "1st Call for H.F.R.I. Research Projects to support Faculty Members & Researchers and the Procurement of High-and the procurement of high-cost research equipment grant" (Project Number: HFRI-FM17-13).

Introduction

There are two areas of theory and research on children's knowledge about the mental world:

The first, referred to as **theory of mind (ToM),** is focused on children's awareness of the representational character of the **other's mind** or the human mind, in general (Hughes et al., 2011).

The second, involving the study of children's **metacognitive skills (MCs),** is focused on the awareness, monitoring and control of **one's own mind**, its cognitive processes and skills (Sodian et al., 2012).

Many recent studies address the contribution of other dimensions of cognitive development (e.g., executive functions) on *either* the development of MCs (e.g., Roebers, 2017) *or* the development of ToM (e.g., Schneider et al., 2014).

However, despite the conceptual and functional similarities in ToM and MCs, their developmental interconnection is scarcely addressed in the literature (Misailidi, 2010).

Aim

This study aimed at investigating the developmental link between ToM and MCs across a wide age-span (from 4 to 12 years of age). It also aimed at detecting the role of executive functions in this relationship.

Method

Participants:

- N= 90 students, equally distributed across the ages from **4 to 12 years of age**.
- Middle socio-economic class.
- Typically developing, with no motor, sensory, linguistic or other developmental disorders.
- Monolingual, L1=Greek.

Procedure:

All children were tested individually, in a quiet room during school hours. Administration of the tasks was completed in 5-7 sessions (depending on children's age) to avoid fatigue.

Measures:

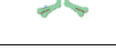
A battery of 9 tasks was administered addressing the following (see, Figure 1):

- executive functions (inhibition, shifting, working memory)
- ToM (1st and 2nd order false-belief tasks)
- Metacognitive off-line estimations acquired through the administration of problem-solving tasks (similarity judgements) and a metalinguistic awareness task

In both ToM and metacognitive tasks, participants were asked to justify their responses.

Figure 1. Tasks

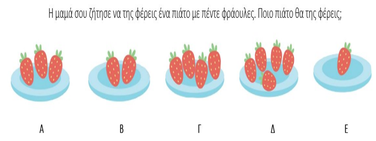
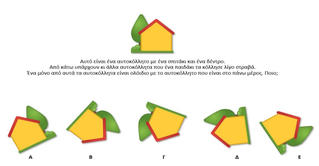
Executive Functions

Inhibition: Animal Stroop task (Stroop, 1935)	Shifting: Day Night Stroop (Gerstadt et al., 1994)	Working memory: Words/Non-words (Demetriou et al., 2008)
		μήλο αυλή θείος βρύση τιρμός αυδή νήττα ήμα

ToM

First order: Smarties Box (Gopnik & Astington, 1988)	Second order: Chocolate Bar (Hughes et al., 2005)
	

Metacognitive off-line similarity judgements on Problem Solving Tasks

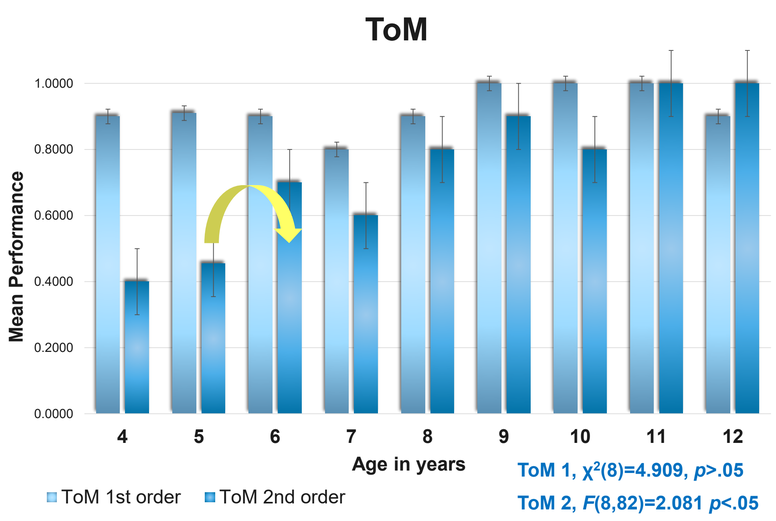
Problem Solving Math: Inspired by Kangaroo	Problem Solving Spatial: Inspired by Kangaroo
	

Metalinguistic awareness

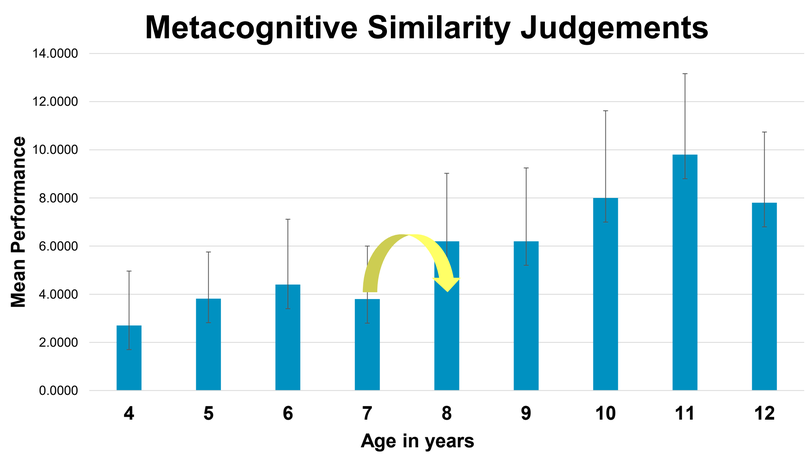
Fafoutas & Maria
(Demetriou et al., 2021)

2.1. Το βιβλίο έπεσε από το τραπέζι

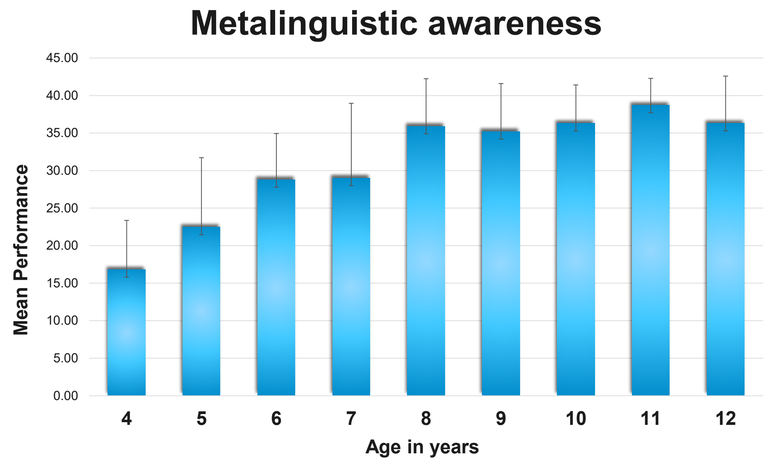
Results



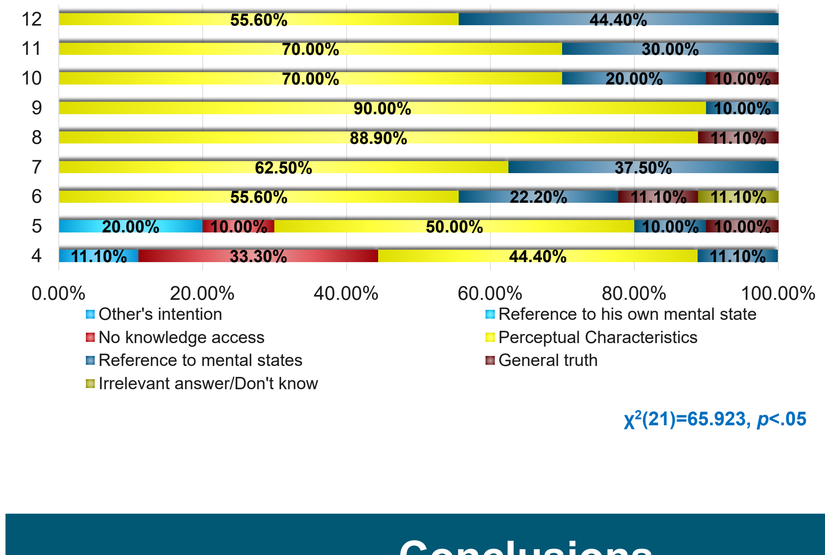
ToM 1, $\chi^2(8)=4.909$, $p>.05$
ToM 2, $F(8,82)=2.081$ $p<.05$



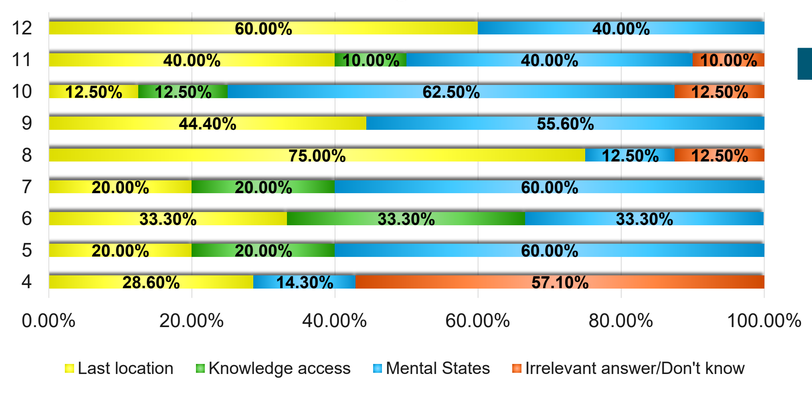
MPS, $F(8,82)=7.145$, $p<.05$



MA, $F(8,82)=11.704$, $p<.05$

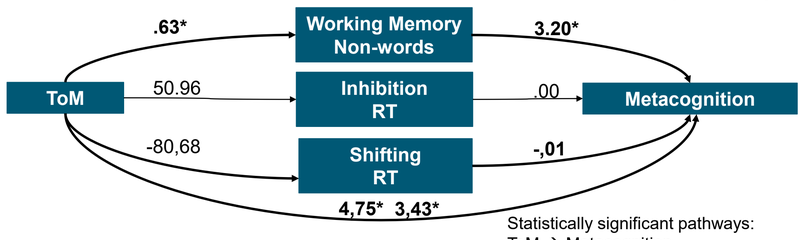


$\chi^2(21)=65.923$, $p<.05$



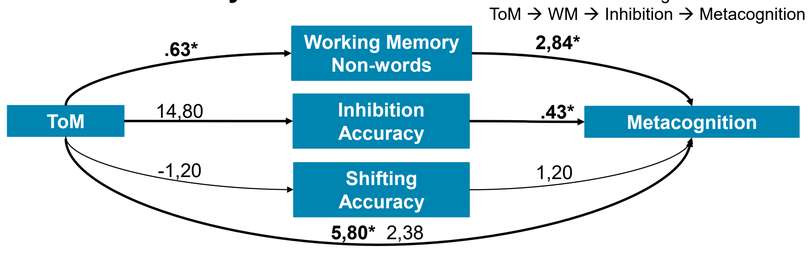
$\chi^2(24)=38.710$, $p<.05$

Mediation Analysis-RT



Statistically significant pathways:
ToM → Metacognition
ToM → WM → Metacognition
ToM → WM → Shifting → Metacognition

Mediation Analysis-ACC



Statistically significant pathways:
ToM → Metacognition
ToM → WM → Metacognition
ToM → WM → Inhibition → Metacognition

Conclusions

- Both ToM and MCs develop significantly during the age span of the study.
- ToM 1 performance is already present at 4 years of age, but ToM 1 justifications gradually indicate understanding of mental states. ToM 2 performance is acquired at 6 years of age and from 11 years is fully established, while the relevant justifications reflect a better understanding of mental states.
- ToM has a significant direct effect on MCs.
- Working memory, efficiency in shifting (RT) and efficacy in inhibition (accuracy) mediate the effect of ToM on MCs.

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