

The Role of Meta-Representation in Children's Development of recursive Theory of Mind and Mental Time Travel

Theoretical Background

- **Recursive thinking:** Embedding of elements within elements of the same kind¹
- Meta-representational ToM: **False Belief** Understanding as recursive capacity: Embedding of representations within representations²
- **Higher-order ToM:** Recursive embedding of meta-representations
- **Structural analog development** of abilities that rely on recursive embedding?³
- **Mental Time Travel:** Representing temporal representations
- **Higher-order Mental Time Travel:** Recursive embedding of temporal representations³

Research question: Do children think at the same level of recursive embedding in ToM and Mental Time Travel?³



Expected patterns of results for ToM and Mental Time Travel

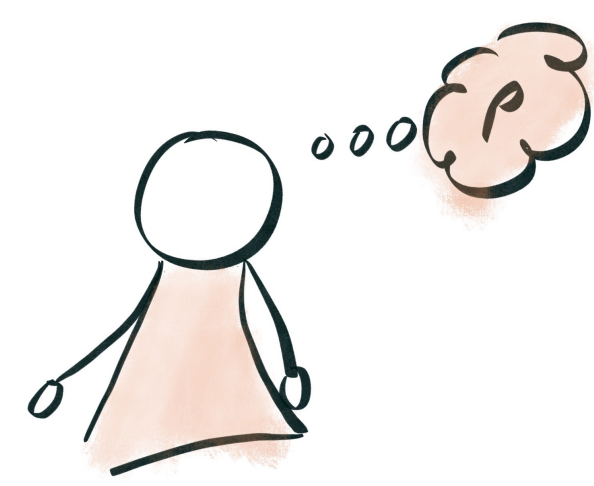
Age	3 years→8 years			
	Pattern A	Pattern B	Pattern C	Pattern D
1. Order Task	—	+	+	+
2. Order Task	—	—	+	+
3. Order Task	—	—	—	+

Methods

Theory of Mind

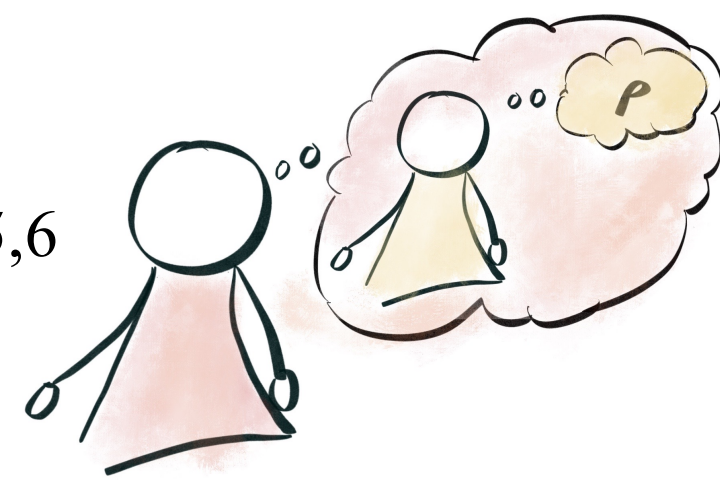
1. Order Task

1. Order FB⁴



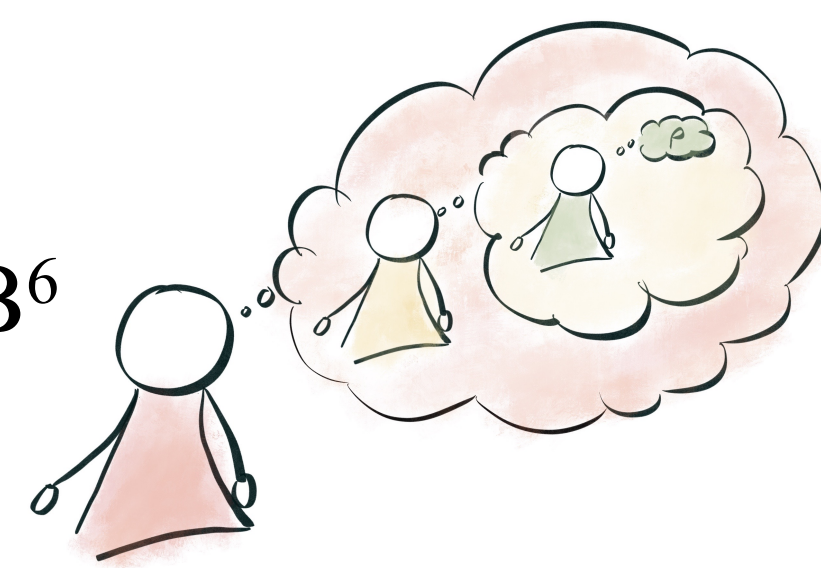
2. Order Task

2. Order FB^{5,6}

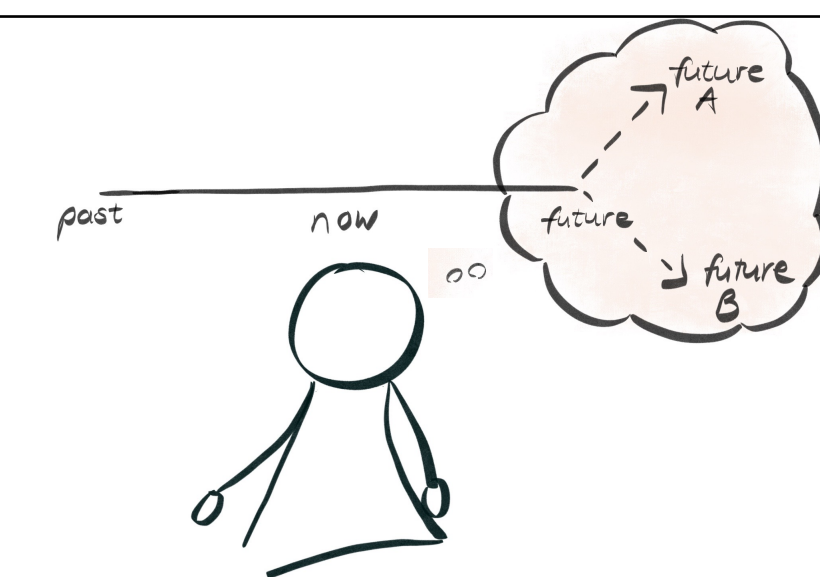


3. Order Task

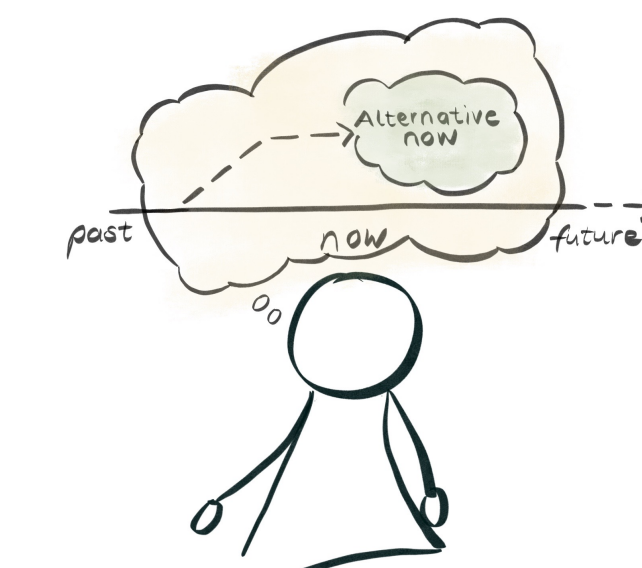
3. Order FB⁶



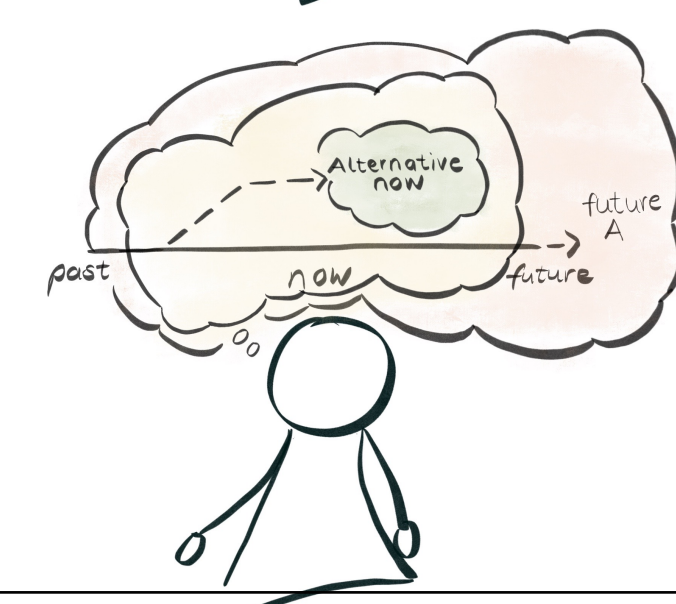
Future possibilities⁷



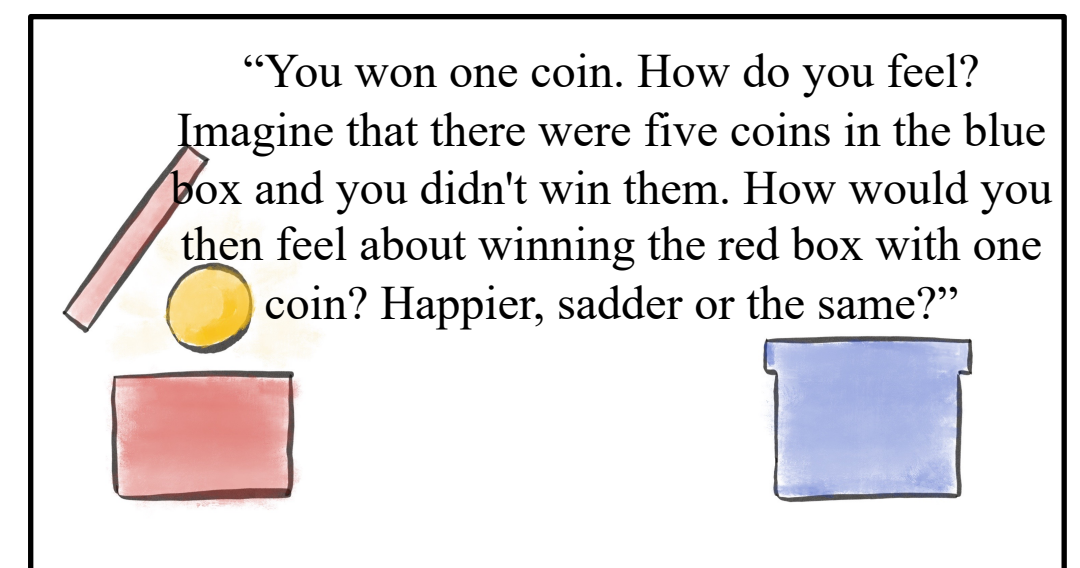
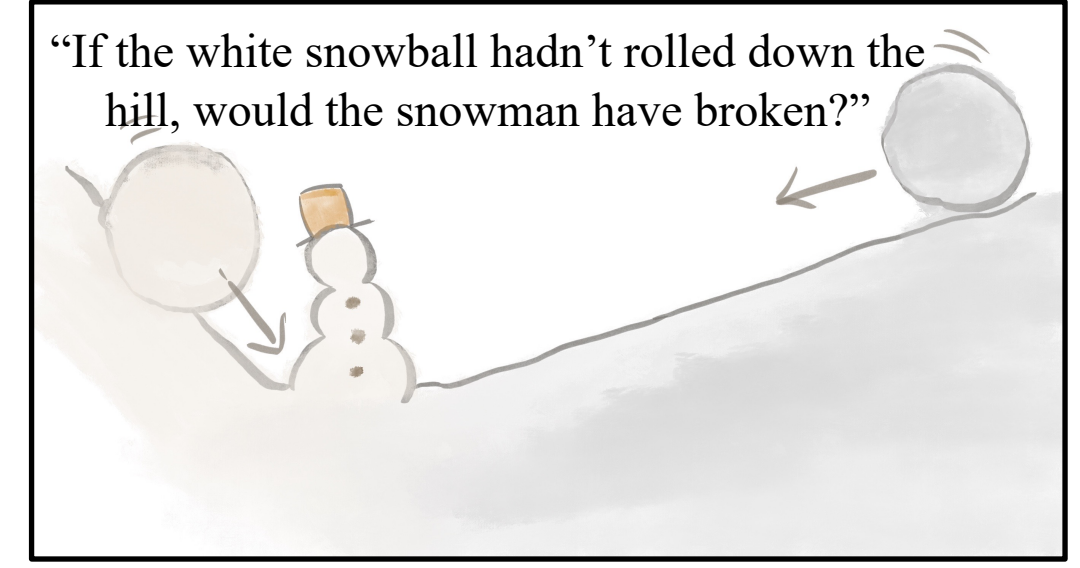
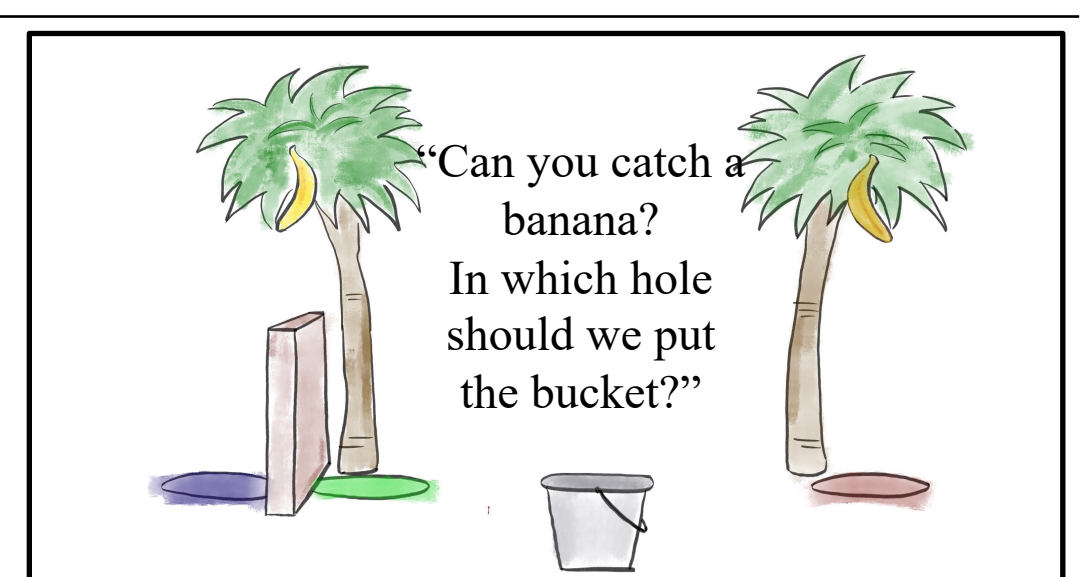
Counterfactual reasoning⁸



Anticipation of counterfactual reasoning: anticipation of regret⁹



Mental Time Travel



Design

Six tasks in two online test sessions

- Test session A:
1. to 3. order ToM tasks
- Test session B:
1. to 3. order MTT tasks

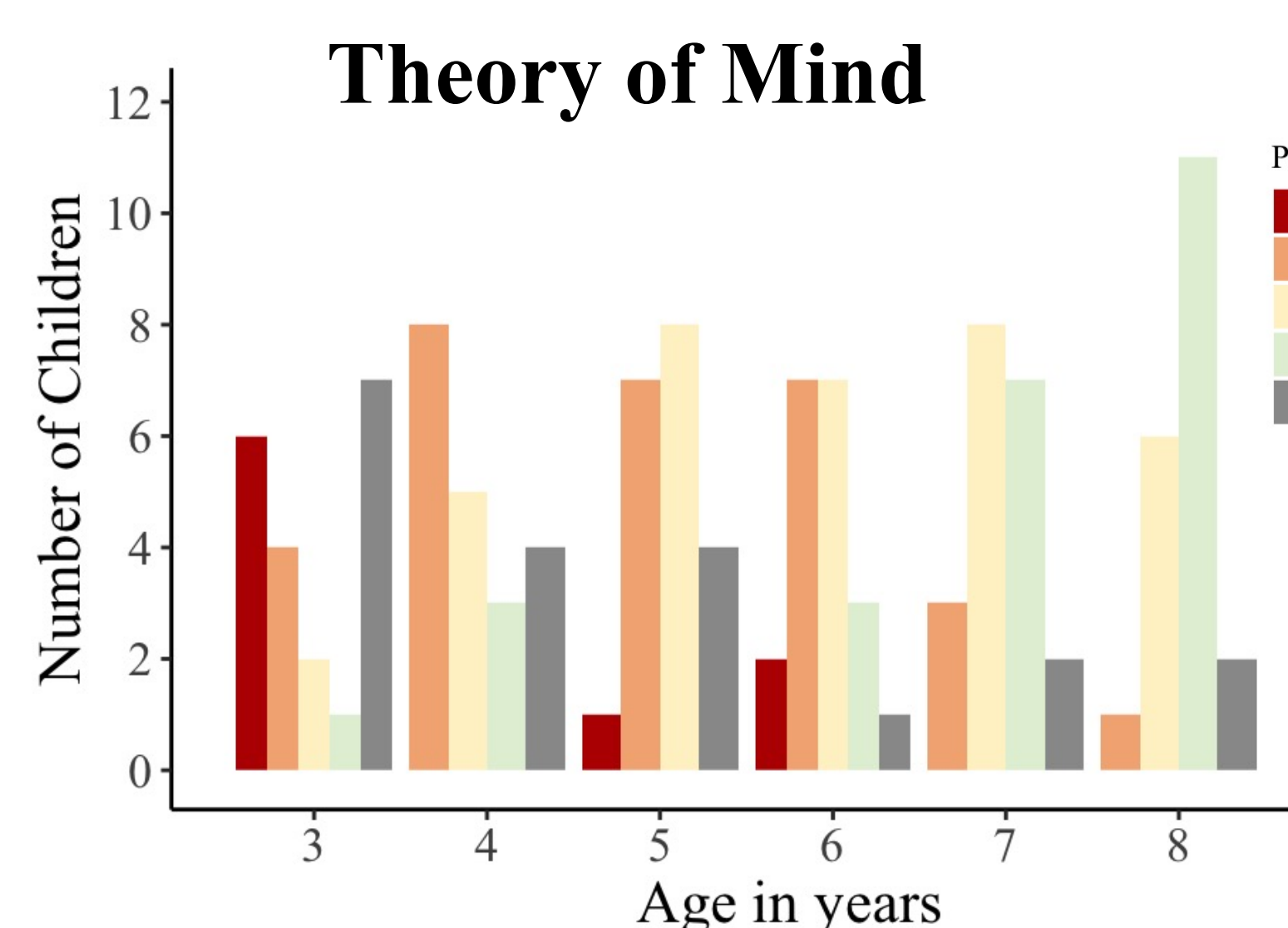
Participants

N = 120 (61 female, 59 male)

- 3-years: n = 20, M = 40.9mon
- 4-years: n = 20, M = 54.0mon
- 5-years: n = 20, M = 65.0mon
- 6-years: n = 20, M = 77.9mon
- 7-years: n = 20, M = 89.8mon
- 8-years: n = 20, M = 101.7mon

Results

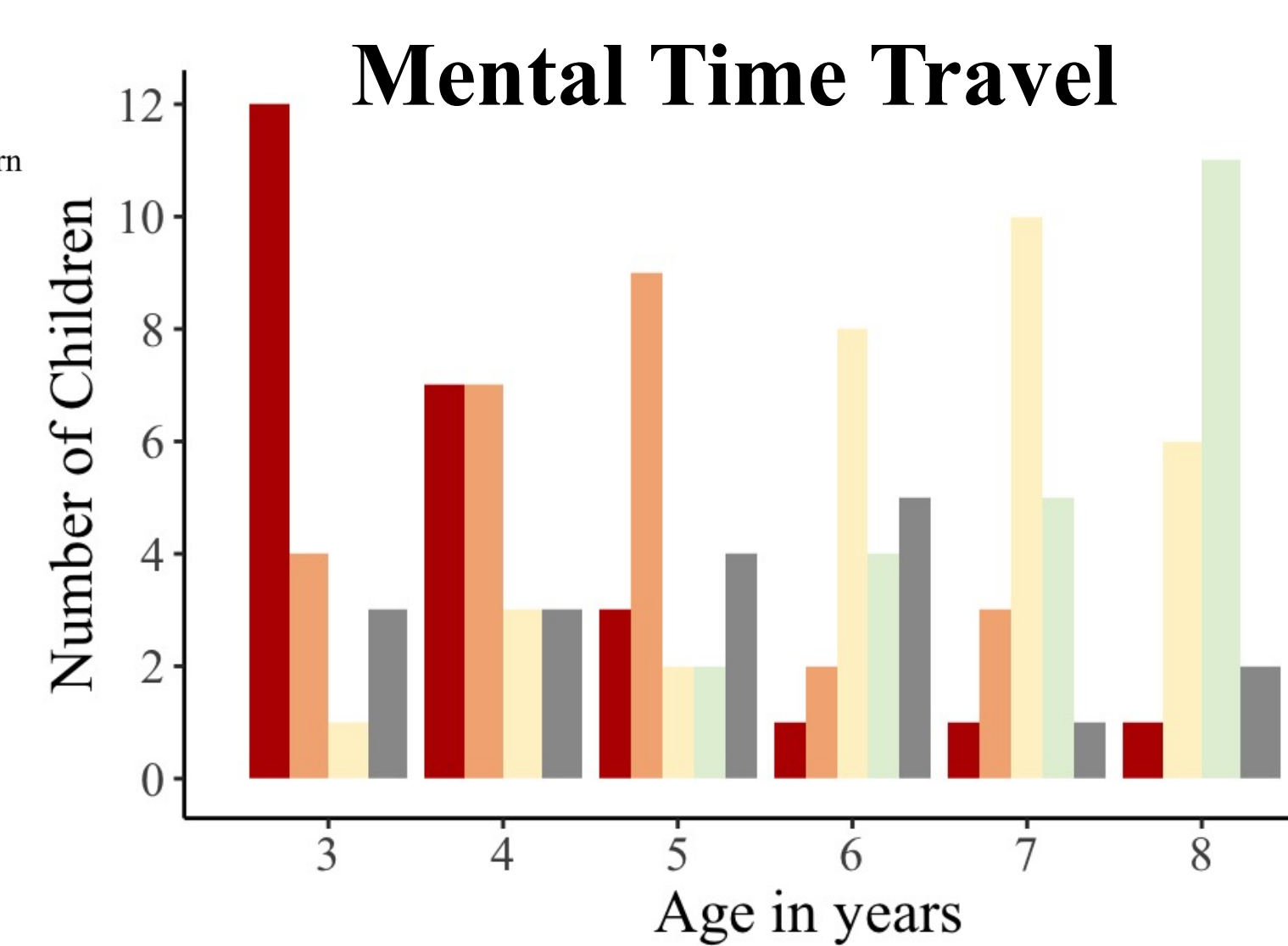
Performance Patterns across Age



Guttman Scale: ToM 1 → ToM 2 → ToM 3
 • Coefficient of Reproducibility: .89
 • Coefficient of Scalability: .66

Pattern	MTT A	MTT B	MTT C	MTT D	MTT other
ToM A	3	4	0	1	1
ToM B	8	9	6	2	5
ToM C	3	8	12	7	6
ToM D	3	1	9	10	2
ToM other	8	3	3	2	4

Weighted Kappa:
K = .31
(without "other")



Guttman Scale: MTT 1 → MTT 2 → MTT 3
 • Coefficient of Reproducibility: .90
 • Coefficient of Scalability: .72

Partial correlations
Controlled for children's age in months
 • 1. order ToM – MTT: $r = .07$ (n.s.)
 • 2. order ToM – MTT: $r = .27$ ***
 • 3. order ToM – MTT: $r = .11$ (n.s.)

MTT pattern ~ age + ToM pattern

Variable	b	β	p
Age (in months)	0.031		< .001
ToM Pattern	0.144		.099
Adj. Multiple R ² : 0.424, p < .001			

Discussion

- Developmental scale for ToM and Mental Time Travel from first to third order of recursive embedding
 - 83% of children in expected pattern in ToM
 - 85% of children in expected pattern in Mental Time Travel
- Fair consistency of performance patterns across abilities
 - Correlation of 2. order tasks only
- Limitation: inconsistent number of trials per level

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References

1. Pinker & Jackendoff, 2005
2. Perner, 1991
3. Gautam et al., 2019
4. Wimmer & Perner, 1983
5. Adapted from Perner & Wimmer, 1985
6. Adapted from Liddle & Nettle, 2006
7. Adapted from Leahy & Žalnierunas, 2021
8. Adapted from McCormack et al., 2018
9. Adapted from McCormack & Feeney, 2015

This is an digital copy of the poster presented at CDS 2022. It contains additional information.