

# Spatial working memory capacity moderates the association between fine motor skills and finger counting / finger montring in preschoolers

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## Research Goal and Hypotheses

We investigate how finger gnosia, fine motor skills (finger agility and object manipulation), and spatial working memory capacity (WM) are associated with preschool children's finger counting and finger montring skills.

- Hypothesis 1:** Finger gnosia, fine motor skills, and spatial WM are associated with finger counting/montring skills
- Hypothesis 2:** Fine motor skills are more strongly associated with finger counting / montring skills than finger gnosia
- Hypothesis 3:** Spatial WM moderates these associations, which should be stronger for children with low WM capacity

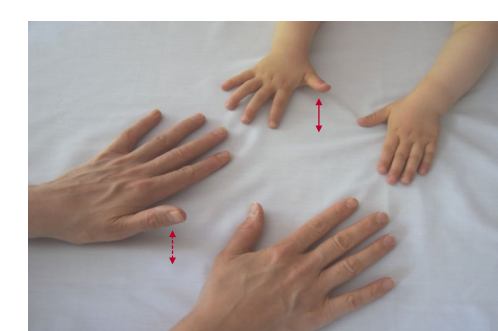
## Participants

- n** = 271 children (127 girls)
- Age:** *M* = 5.0 years, *SD* = 9.78, range: 40 - 81 months
- Handedness:** 246 right, 17 left, 1 alternating
- Datasets from two studies (*n* = 141 and *n* = 155)
  - Mostly identical tasks
  - 25 participants excluded due to missing data
  - Data collection 2018-2020 in Southern Germany

## Tasks

### Finger gnosia

- Non-motoric task: Is the same finger touched on the child's hand and the drawing?
- 7 items, 0-7 points

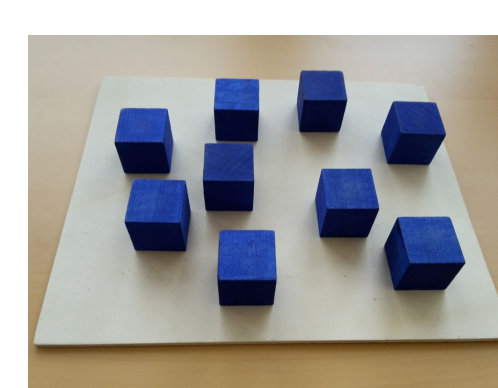
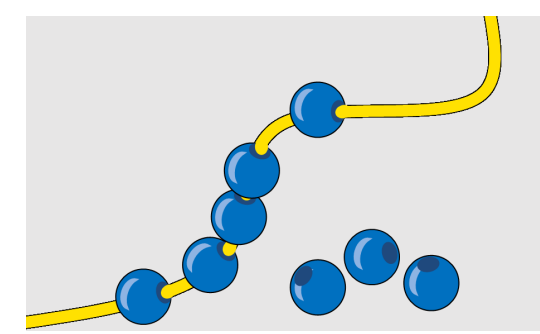


### Fine motor skill: Finger agility

- Lift the same finger as the experimenter and tap it on the table while not moving other fingers
- 16 items, 0-16 points

### Fine motor skill: Object manipulation

- Thread 6-12 beads as fast as possible (MABC-2<sup>6</sup>)
- 2 trials, faster one is scored in sec.

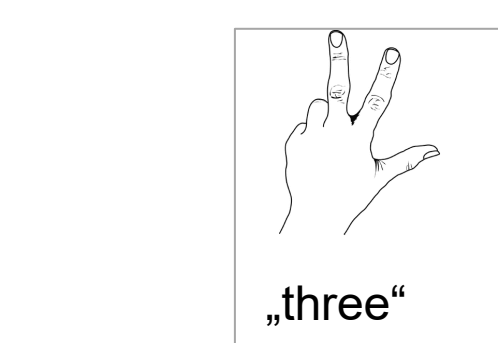
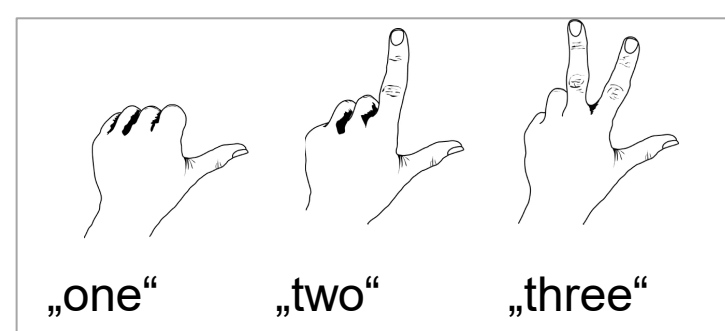


### Spatial working memory

- Corsi Block Tapping Task, Backward: Copying a sequence of tapped blocks in reverse order
- Two trials per span
- Longest correctly replicated span → WM span

### Finger counting

- Count to X on your fingers (e.g., «three»)
- 6 items (numbers 2-7), 0-6 points



### Finger montring

- Show me X fingers (e.g., «three»)
- 6 items (numbers 2-7), 0-6 points

## Descriptive Statistics

Table 1. Descriptive Statistics

	N	min	max	M	SD	Skew	Kurtosis
Age in months	271	40	81	59.53	9.78	.404	-.861
Finger gnosia (sum of solved items)	271	0	7	4.74	1.31	-.252	.063
Finger agility (sum of solved items)	270	0	16	10.46	3.85	-.561	-.152
Object manipulation (time in seconds)	271	19	205	47.22	21.51	2.78	13.49
Spatial WM (backward span)	247	0	6	2.63	1.57	.161	-.235
Finger counting (sum of solved items)	269	0	6	5.19	1.51	-2.04	3.26
Finger montring (sum of solved items)	267	0	6	4.97	1.51	-1.509	1.491

## Analytical Approach

- Z-transformation of all data
- Partial Spearman correlations controlling for age
- Multiple linear regression models
- Moderation analyses with simple slopes for WM (Using the SPSS PROCESS macro 4.0<sup>7</sup>).

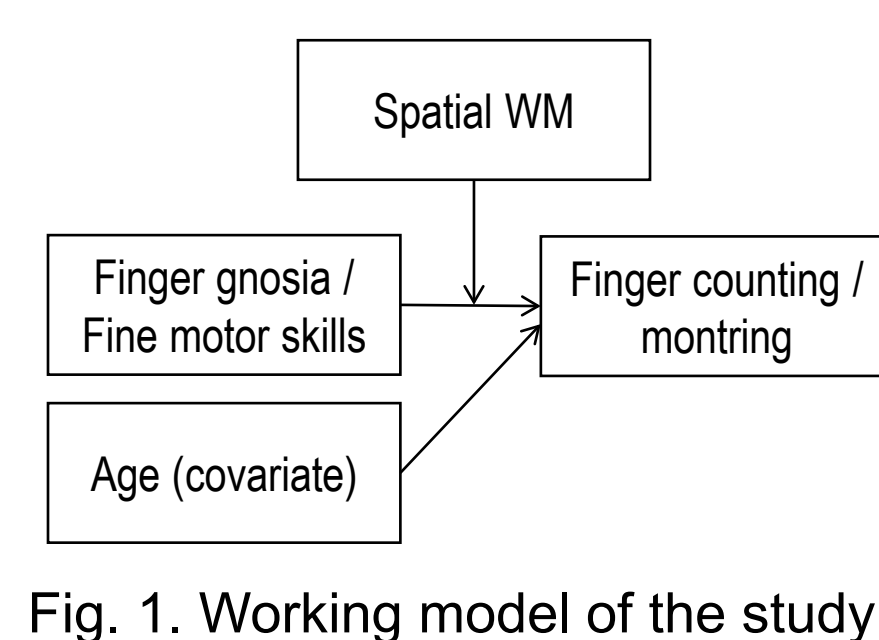


Fig. 1. Working model of the study

## Theoretical Background

- Finger gnosia, fine motor skills, and spatial working memory (WM) have been identified as domain-general precursor skills to children's early numerical and mathematical competencies<sup>1,2,3</sup>
- WM in particular has been consistently associated with mathematical skills, specifically so in children with mathematical difficulties<sup>4</sup>
- Finger gnosia and fine motor skills, in turn, are reportedly more strongly related to basic numerical skills and have been argued to impact early finger counting (counting on one's fingers) and finger montring skills (displaying numerical magnitudes with one's hands)<sup>5</sup>
- However, it is unclear how children's spatial WM capacity impacts the effect that finger gnosia and fine motor skills might have on their ability to count or represent magnitudes with their fingers

## Results Hypotheses 1+2: Associations

Table 2. Partial Spearman correlation coefficients controlling for age.

	1	2	3	4	5
1 Finger counting	--				
2 Finger montring	.569**	--			
3 Finger gnosia	.101	.116	--		
4 Finger agility	.222**	.148*	.069	--	
5 Object manipulation	.142*	.165**	.030	.174**	--
6 Spatial WM	.207**	.175**	.166**	.085	.187**

\*\* = *p* < .01. \* = *p* < .05

## Results Hypothesis 3: Moderating Effects of Spatial Working Memory

### Spatial WM moderating the association between finger agility and finger counting

Effects on finger counting	$\beta$	SE $\beta$
Finger agility	.207**	.056
Spatial WM	.216**	.063
Finger agility x Spatial WM	-.177**	.059
Age	.156*	.065

Table 4. Results of moderation analysis

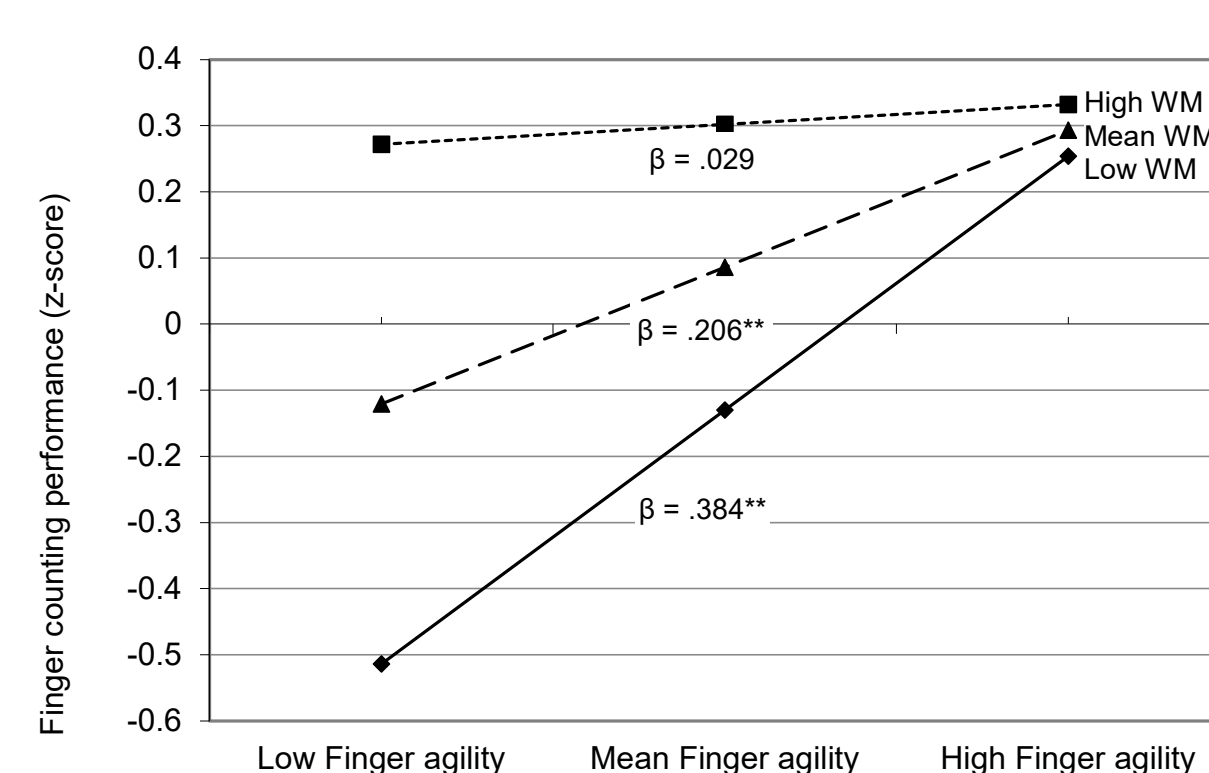


Fig. 2. Simple slopes of the interaction between finger agility and spatial WM

Table 3. Multiple linear regression models predicting finger counting and finger montring.

	Finger counting			Finger montring		
	B	SE B	$\beta$	B	SE B	$\beta$
Intercept	.044	.053		.046	.054	
Finger gnosia	.067	.056	.072	.082	.057	.086
Finger agility	.203	.058	.214**	.136	.059	.138*
Object manipulation	.121	.061	.121*	.166	.063	.158**
Spatial WM	.176	.066	.191**	.194	.067	.206**
Age	.123	.066	.132	.160	.067	.168*
R <sup>2</sup>	.226**			.239**		

### Spatial WM moderating the association between finger agility and finger montring

Effects on finger montring	B	SE $\beta$
Finger agility	.149*	.058
Spatial WM	.249**	.065
Finger agility x Spatial WM	-.153*	.060
Age	.187**	.067

Table 5. Results of moderation analysis

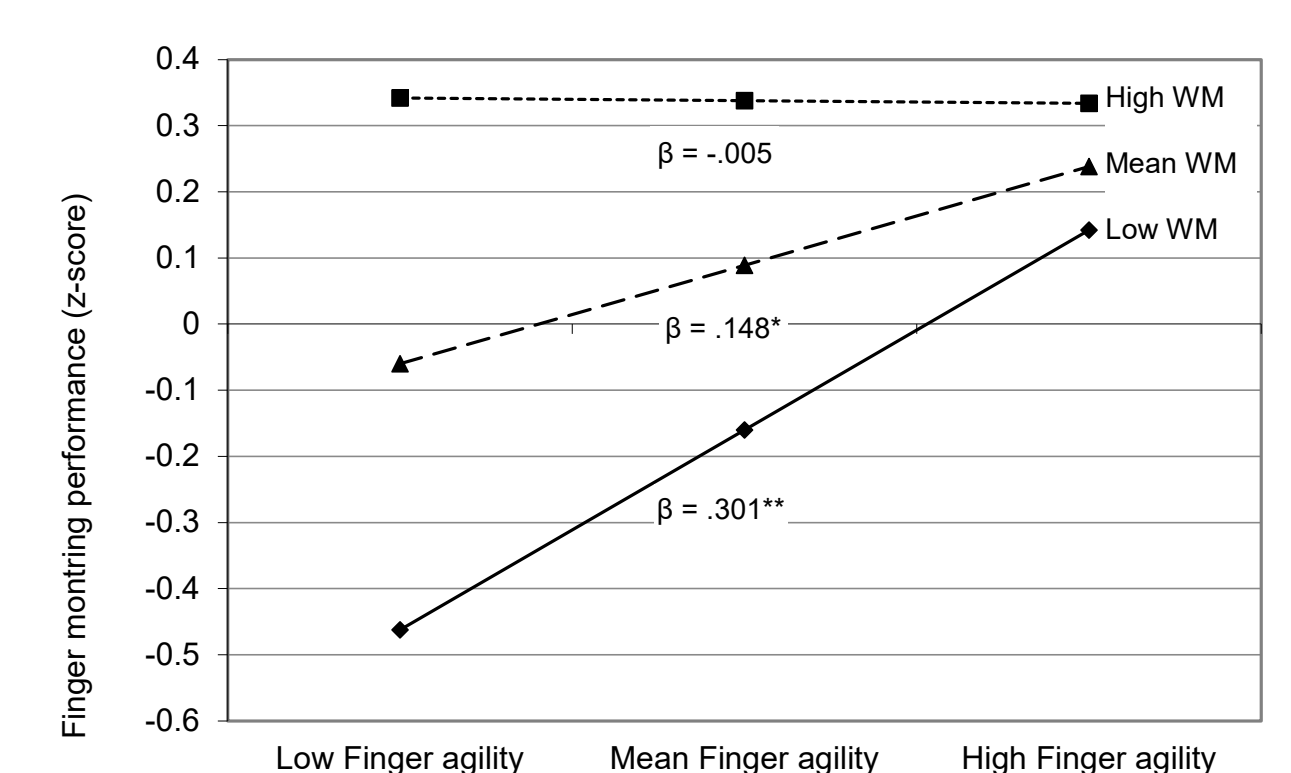


Fig. 3. Simple slopes of the interaction between finger agility and spatial WM

### Spatial WM moderating the association between object manipulation and finger counting

Effects on finger counting	$\beta$	SE $\beta$
Object manipulation	.079	.067
Spatial WM	.239**	.068
Object manipulation x Spatial WM	-.194**	.063
Age	.206**	.065

Table 6. Results of moderation analysis

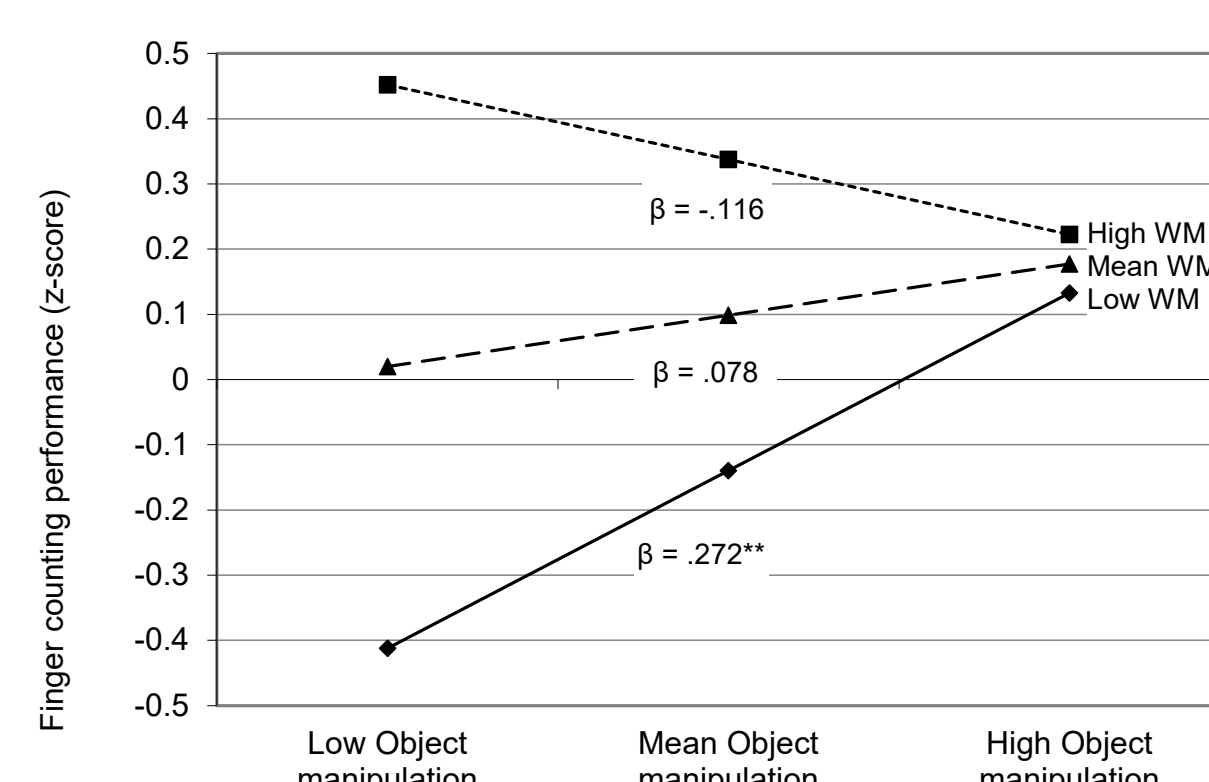


Fig. 4. Simple slopes of the interaction between object manipulation and spatial WM

### Spatial WM moderating the association between object manipulation and finger montring

Effects on finger montring	$\beta$	SE $\beta$
Object manipulation	.105	.069
Spatial WM	.257**	.068
Object manipulation x Spatial WM	-.185**	.063
Age	.230**	.066

Table 7. Results of moderation analysis

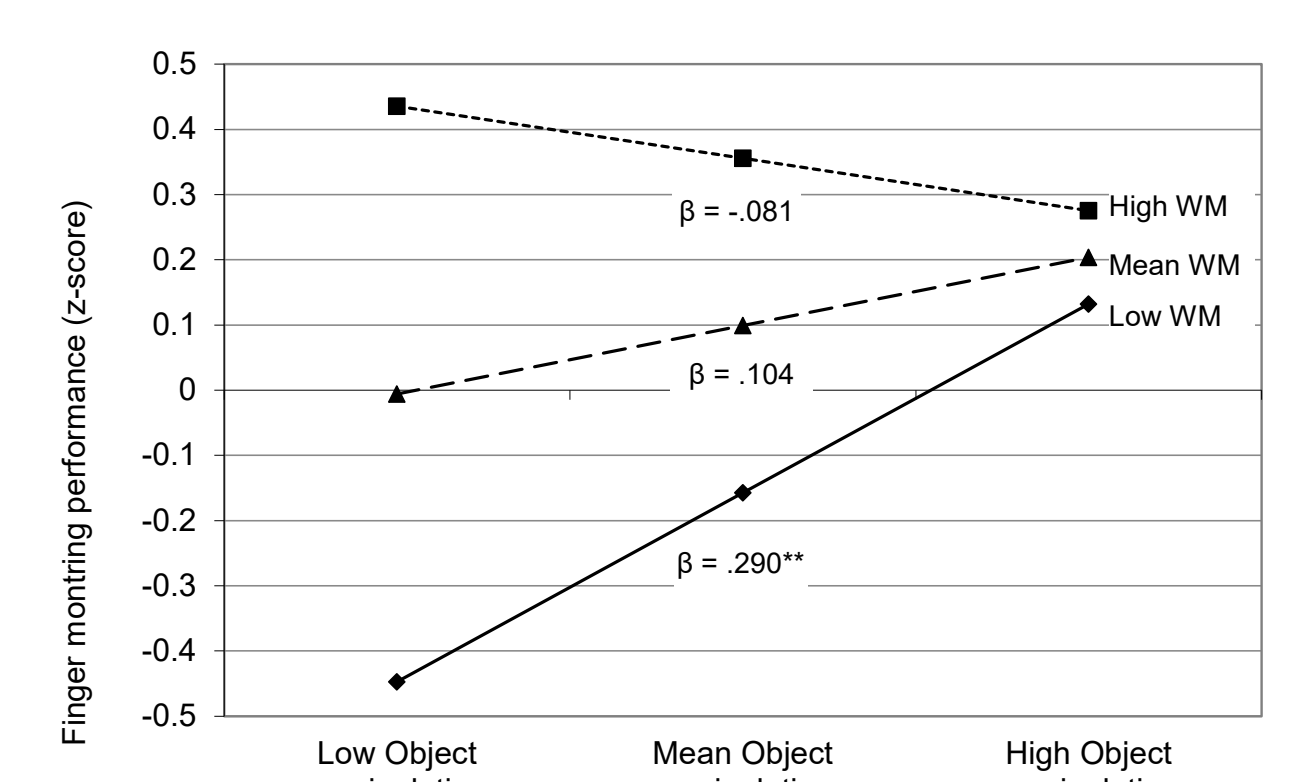


Fig. 5. Simple slopes of the interaction between object manipulation and spatial WM

## Summary and Discussion

- Children's fine motor skills and spatial WM capacity, but not finger gnosia, were significantly associated with their finger counting/montring skills
- Spatial WM capacity moderates the association between fine motor skills and finger counting / montring skills, which is strongest for children with low WM capacity and not significant for children with high WM capacity
- Children with low spatial WM capacity might rely more on their fine motor skills to count / display magnitudes with their fingers compared to children with high working memory capacity, who might not need to
- Future research and intervention on finger counting skills should consider both spatial WM and fine motor skills

## Literature

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