Understanding numerical size through our body

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Numbers and magnitude in the brain:

A sensorimotor grounding of numerical cognition

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Tschentscher et al., 2012



Tschentscher et al., 2012



Andres et al., 2012

There is clear evidence for an important role of finger representations in numerical (arithmetic) processing!

There is clear evidence for an important role of finger representations in numerical (arithmetic) processing!

However, fingers themselves have nothing to do with magnitude!

























Spatial-Numerical Association of Response Codes



Dehaene, et al., 1993





Cutini et al., 2012

Knops et al., 2009




Fischer, et al., 2011



Fischer, et al., 2011

Link, et al., 2013



Addition task: performance changes through training conditions.

	Single-digit sums n=24		Carry problems		Two-digit sums	
					n=22	
	Mean	sd	Mean	sd	Mean	sd
<i>Efficiency score</i> Embodied Control	733 268	1124 841	1903 - 308	2997 2948	505 272	1833 1253
Standardized RT Embodied Control	10% 17%	21 21	20% 31%	41 125	3% 3%	28 62
Error rate Embodied Control	10% - 10%	15 10	- 5% - 7%	53 61	2% 5%	23 19





Link, et al., 2013

There is clear evidence for an important role of positional space in numerical (arithmetic) processing!

There is clear evidence for an important role of positional space in numerical (arithmetic) processing!

However, spatial positions themselves have nothing to do with magnitude!



















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Semantically distant



Semantically close

































Interaction between perceptual magnitude and motor magnitude



Krause et al., in preparation

Interaction between perceptual magnitude and motor magnitude





Krause et al., in preparation












































Spatial-Numerical Association of Response Codes



Left press

Krause et al., 2014

Right press













<u>Force-Numerical Association of Response Codes</u>



Interaction numbers - space

Interaction numbers - force

Interaction numbers - space

Interaction numbers - force



Participants

Interaction numbers - space

Interaction numbers - force



Participants









• an interaction between numbers and physical size

- an interaction between numbers and physical size
- an interaction between numbers and tactile stimulation amount

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- an interaction between perceptual and motor magnitudes in early childhood

- an interaction between numbers and physical size
- an interaction between numbers and tactile stimulation amount
- an interaction between perceptual and motor magnitudes in early childhood
- an anatomical dissociation in the brain between the dispositions to link numbers to either positional space or motor force







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- Size-related bodily representation of numbers do play an important role
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- There seem to be multiple *qualitatively* different ways to represent (and hence to understand) numbers
- Size-related bodily representation of numbers do play an important role
- Individuals seem to differ in the way they mentally represent numbers

• How do these representations contribute to math/arithmetic capabilities?

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- Do these representations contribute differently?
- Is one representation maybe more important for math/arithmetic than the other?
- Can a sensorimotor magnitude training improve math/arithmetic performance?
- How do different representations relate to math/arithmetic deficiencies (e.g. Dyscalculia)?

Special thanks to



Oliver Lindemann

inivers)

Porsdam



Harold Bekkering



Ivan Toni



Marlene Meyer



Sabine Hunnius









Thank you for your attention!