



# Typical & Atypical Cognitive Development

## Unit 0. Introduction into course topics and course structure

15<sup>th</sup> February 2019

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# COURSE STRUCTURE AND REQUIREMENTS

- Structure
  - 60- minutes lecture in English (introducing the topic); Paul Seitlinger
  - followed by a 60-minutes seminar in Estonian (deepening the introduced course content); Grete Arro and Kati Aus
- Requirements
  - Being prepared for every unit
    - Reflecting on previous unit (in written form, answering 3-5 questions)
    - Answering questions on an article introducing some of the next unit's topics (in written form, answering 3-5 questions)
  - Taking online exam
    - Open-ended questions on presented course contents

# **COURSE TOPICS**

## **Unit 1 (8<sup>th</sup> of March, T-412)**

- Cognitive development from the nature-nurture perspective? What is the impact of genes versus environment?

## **Unit 2 (15<sup>th</sup> of March, T-412)**

- How does the cognitive system develop? What are typical developmental stages? How do these stages relate to different cognitive components?

## **Unit 3 (22<sup>nd</sup> of March, T-412)**

- What are potential reasons for individual differences in (typical and atypical) cognitive development?

## **Unit 4 (5<sup>th</sup> of April, T-412)**

- How can we diagnose/measure and how can we train cognitive abilities?

## **Unit 5 (12<sup>th</sup> of April, T-412)**

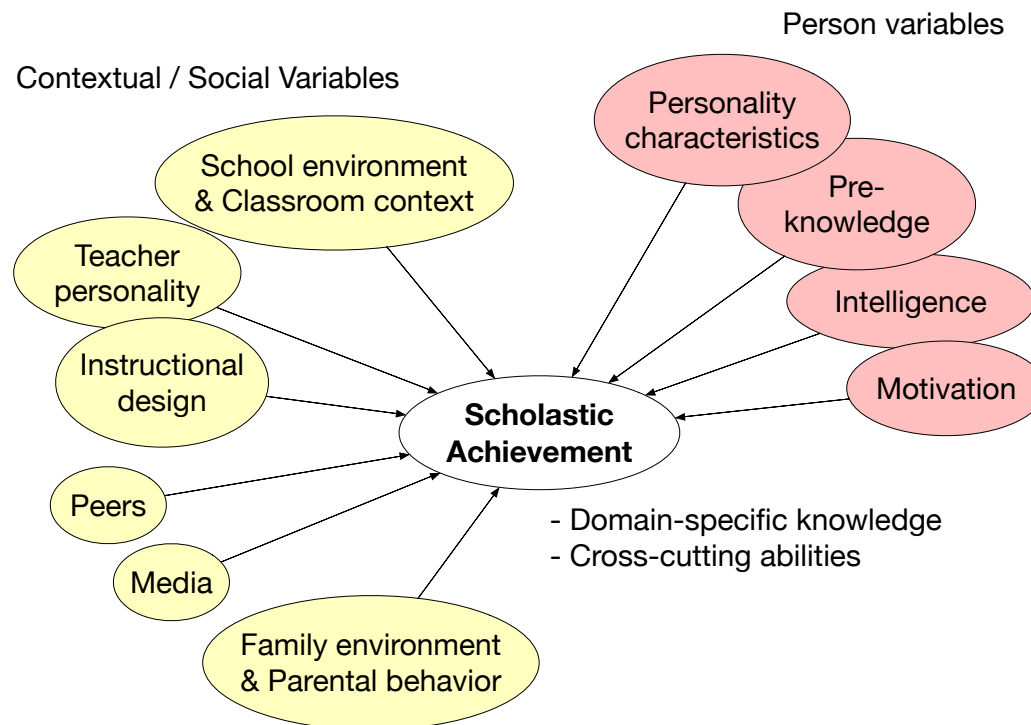
- How can we design Discovery Learning in an inclusive way?

## **Exam (20<sup>th</sup> of April, Web-based)**

# WHY COGNITION MATTERS

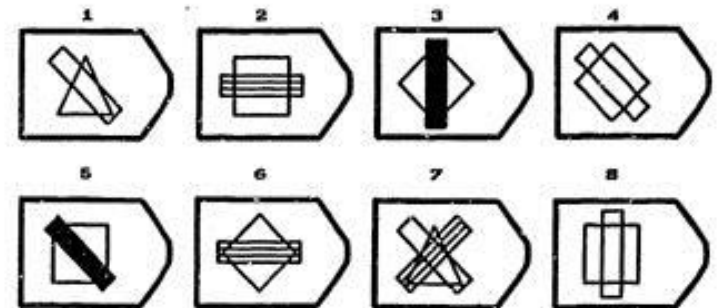
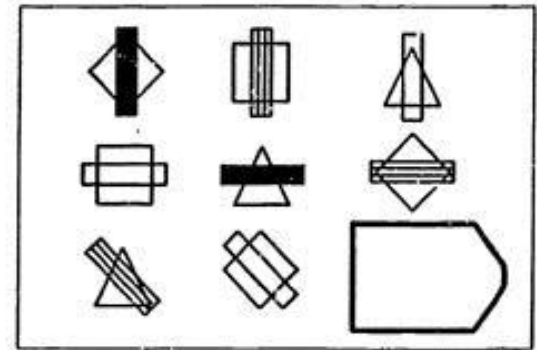
Determinants of scholastic achievement (based on Brühwiler & Helmke, 2018)

**Which of these variables has the strongest impact?**



# WHY COGNITION MATTERS

- Intelligence is one of the strongest predictors of educational achievement (e.g., Hattie, 2009)
- What is intelligence?
  - A general mental capacity to draw conclusions, to plan, to solve problems, to reason in abstract categories, to acquire new knowledge
  - Typically, the performance in tests with mentally demanding tasks
  - Relatively stable personality trait



*Example of Raven matrices IQ test*

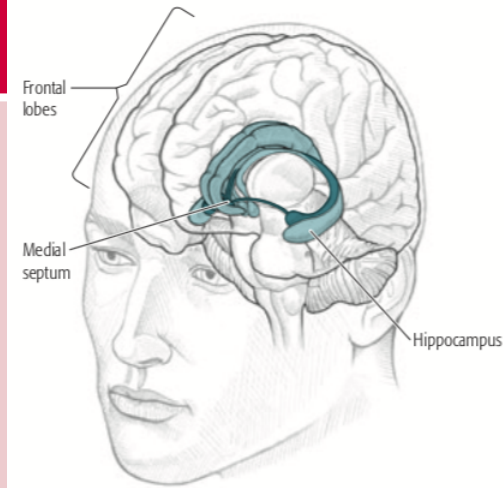
# WHY COGNITION MATTERS

- More intelligent/gifted students are better (faster and more effective) in
    - recognizing regularities and rules relevant for solving problems
    - acquiring and organizing knowledge
  - *Learning scenarios of future school curricula become more challenging*
    - *E.g., Discovery Learning: Self-directed information search in addition to knowledge acquisition*
- *Performance differences among more and less gifted students might become larger*
- Urgent questions in education:
- How to design future education in an inclusive way?
  - What are effective strategies to help less well-equipped children in school?

# POTENTIAL APPROACH TOWARDS INCLUSIVE EDUCATION

- Looking at intelligence in a more nuanced way: what are the cognitive components that bring about intelligent behavior?

Basic functions (examples)	Emerging cognitive processes (examples)	Involved brain structures (examples)
Learning new things	<ul style="list-style-type: none"> <li>Thinking &amp; Thinking about thinking</li> <li>Reading</li> <li>Drawing conclusions</li> <li>Imagination</li> <li>Planning</li> <li>Decision-making</li> <li>Problem solving</li> <li>...</li> </ul>	<p>Interplay of</p> <ul style="list-style-type: none"> <li>Working Memory (at the front of the brain = Pre-Frontal lobe)</li> <li>Long-Term Memory (e.g., Hippocampus, temporal lobe)</li> </ul>
Remembering old things that matter		
Manipulating remembered things		
Controlling attention		



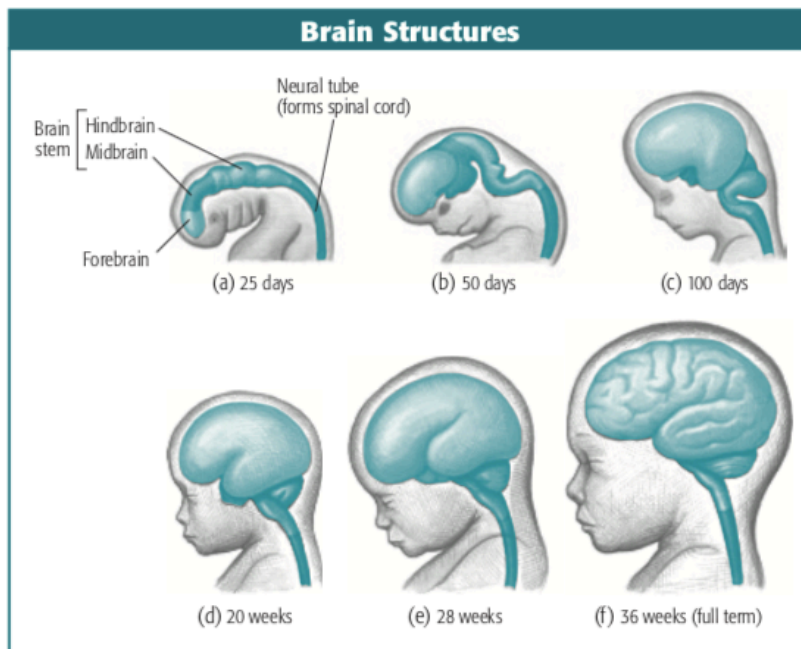
- Identifying regularities in how these components develop during childhood
- Deriving ways and strategies to support cognitive development

# WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

Bio-psychological facts on our learnability (neural plasticity)

1. Humans have large brains relative to their body size

→ **Much of neural development postponed until after birth**



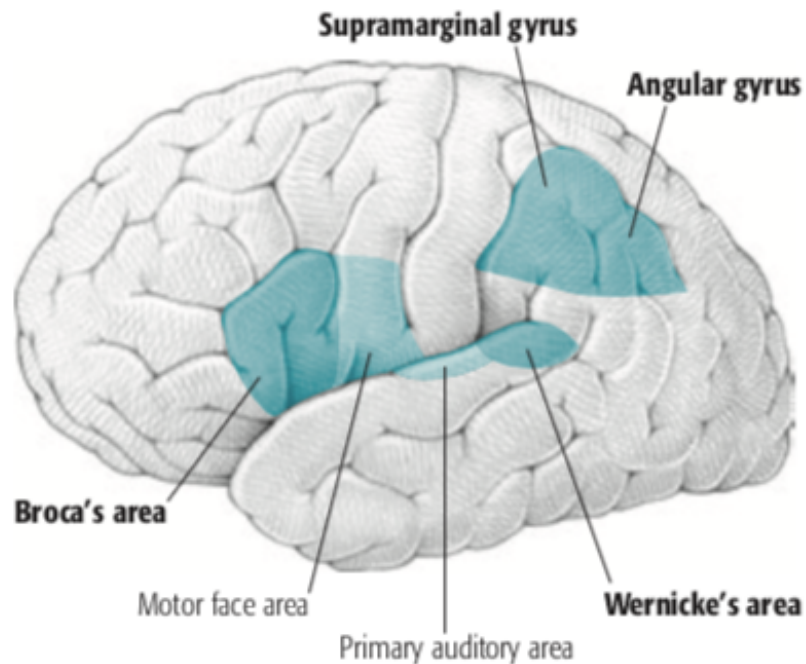
- Though birth canal expanded to its limits, brain size can't be larger than 350 cm<sup>3</sup> at birth
- Doubles in 1<sup>st</sup> year of life: 700 cm<sup>3</sup>
- Soon after, growth rate slows down but the volume again doubles before reaching puberty: 1.400 cm<sup>3</sup>
- **Prolonged time of development**
  - about 15 years ~ 1/5 of the human life span
  - **needed to acquire complex cultural practices, such as language**

*Picture taken from Anderson (2015)*



# WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

Cognitive development (like learning your mother tongue) = Development of neural “communication structure”



- All **cognition** (e.g., understanding and producing words) is **distributed** across **specialized areas** that
  - **play specific roles**, such as
    - comprehension of words (Wernicke's area)
    - production of words (Broca's area)
  - **communicate** to exchange their processing products (e.g., meaning and sound of a word)

*Picture taken from Anderson (2015)*

# WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

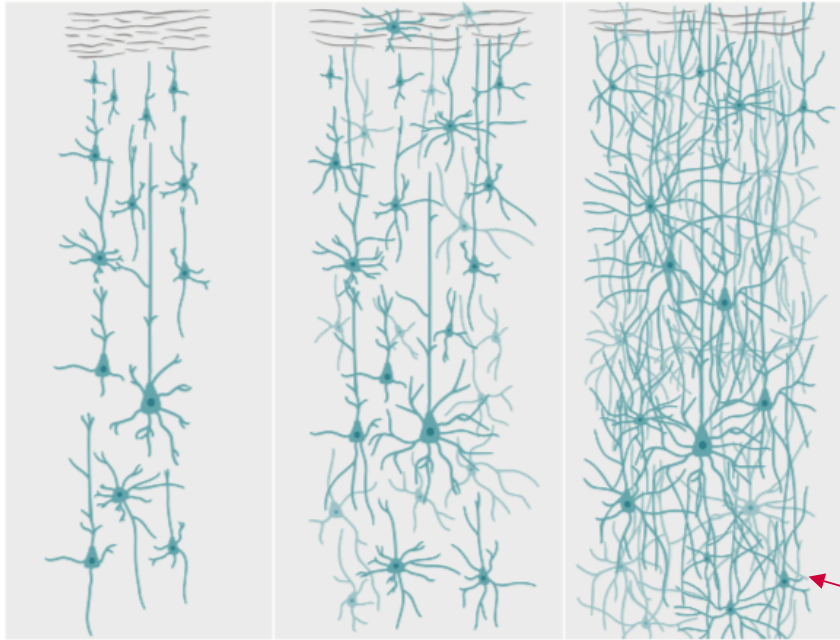
Cognitive development = Development of neural “communication structure”

*Brain development around **Broca's** area*

*Newborn*

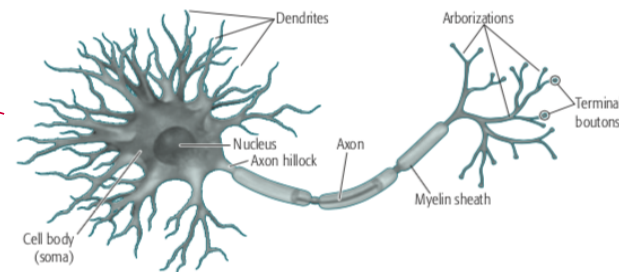
*3 months*

*24 months*



*Picture taken from Anderson (2015)*

- Neural communication is based on
  - neurons (basic processing units)
  - connections between neurons = **Synapses**
- Learning to represent knowledge (e.g., word meaning) by building up new synaptic connections between neurons
  - **Synaptogenesis** peaks around the age of 2
  - Soon after, elimination of unnecessary structure = **Synaptic pruning** for **neural efficiency** (saving energy)



# WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

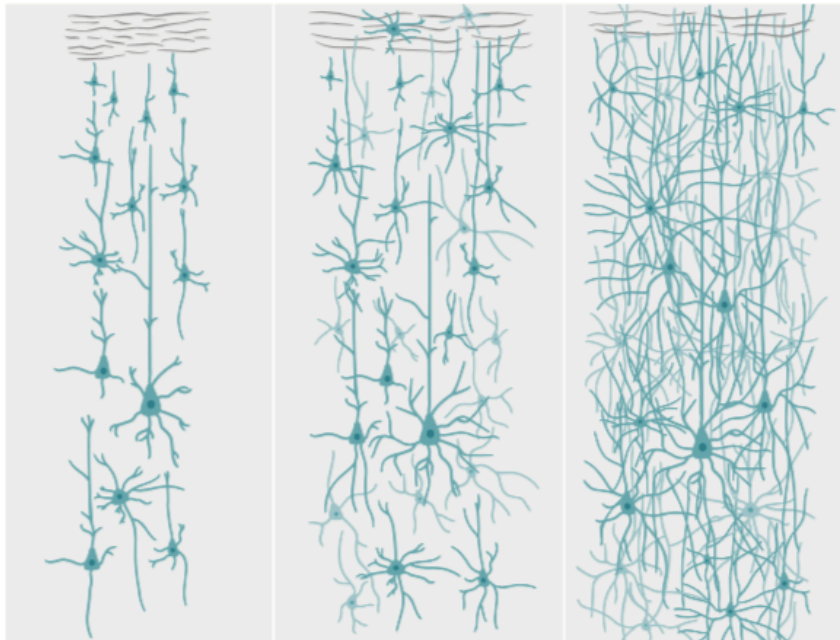
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*Newborn*

*3 months*

*24 months*



- **Synaptic pruning**

[https://www.youtube.com/watch?v=rxPT78F\\_ZVE&feature=share](https://www.youtube.com/watch?v=rxPT78F_ZVE&feature=share)

- Between the ages of **2 and 16**
  - “**Use it or lose it**” principle
    - Constant stimulation → synapses become stronger and permanent
    - Little stimulation → elimination
- Interplay of biology (**nature**) and learning experiences (**nurture**)
- Education: helping to separate the important from the less important experiences / neural stimulations

*Picture taken from Anderson (2015)*

# WHY DOES COGNITION MATTER FOR EDUCATION?

## Summary and some first conclusions

- New learning scenarios place high cognitive demands on students  
→ *A need for strategies to let less gifted students participate and benefit as well*
- Human cognition
  - is distributed across communicating and specialized brain areas
    - Neural communication based on synapses connecting simple processing units (neurons)
  - Synaptic pruning
    - helps to save energy and fine-tune the brain
- Learning and cognitive development takes place as an interplay between
  - the formation of important and the pruning of unimportant synapses
  - genetic factors and environmental learning experiences  
→ *Specific knowledge about our cognitive system and how it develops to realize beneficial learning experiences in everyday school life*

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# LITERATURE OF TODAY'S SESSION

- Anderson, J. (2015). [Cognitive psychology and its implications \(8<sup>th</sup> edition\)](#). New York, NY: Worth Publishers.
  - Parts of chapter 1 (“The Science of Cognition”) and chapter 14 (“Individual Differences in Cognition”)